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PETRIFACTIONS

AND THEIR TEACHINGS.

LONDON:
R. CLAY, PRINTER, BREAD STREET HILL.

Notornis Mantelli

see page 126.

PETRIFACTIONS AND THEIR TEACHINGS;

OR,

A HAND-BOOK

TO THE GALLERY OF ORGANIC REMAINS

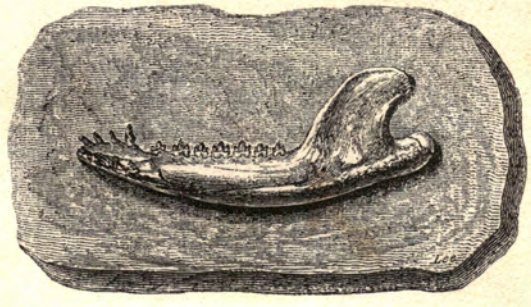
OF

The British Museum.

BY

GIDEON ALGERNON MANTELL, ESQ. LL.D. F.R.S.

HONORARY FELLOW OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND, ETC.; AUTHOR OF "THE MEDALS OF CREATION," "THE WONDERS OF GEOLOGY," "THOUGHTS ON ANIMALCULES," ETC.



JAW OF A MAMMALIAN QUADRUPED, IN OOLITIC LIMESTONE, FROM STONESFIELD.
Page 403.

"Grand monuments of Nature, which mark the past revolutions of the Globe."
Sir H. Davy.

WITH NUMEROUS ILLUSTRATIONS.

LONDON:
HENRY G. BOHN, YORK STREET, COVENT GARDEN.
MDCCCLI.

TO THE

RIGHT HONOURABLE AND HONOURABLE

THE TRUSTEES OF THE BRITISH MUSEUM,

HIS GRACE JOHN BIRD LORD ARCHBISHOP OF CANTERBURY,

THOMAS LORD TRURO LORD HIGH CHANCELLOR,

RIGHT HON. CHARLES SHAW LEFEVRE SPEAKER OF
THE HOUSE OF COMMONS,

&c. &c. &c.

THIS ATTEMPT TO RENDER

THE GALLERY OF ORGANIC REMAINS

MORE INTERESTING AND INSTRUCTIVE TO THE PUBLIC IN GENERAL,

AND MORE CONDUCIVE TO THE ADVANCEMENT OF

SCIENTIFIC KNOWLEDGE,

BY CONNECTING THE GEOLOGICAL HISTORY

OF THE MOST IMPORTANT SPECIMENS WITH DESCRIPTIONS

OF THEIR ORGANIC CHARACTERS AND RELATIONS,

IS MOST RESPECTFULLY DEDICATED

BY

THE AUTHOR.

11*th October*, 1851,
CHESTER SQUARE,
PIMLICO, LONDON.

" If we look with wonder upon the great remains of human works, such as the columns of Palmyra, broken in the midst of the desert; the temples of Pæstum, beautiful in the decay of twenty centuries; or the mutilated fragments of Greek sculpture in the Acropolis of Athens, or in our own museums, as proofs of the genius of artists, and power and riches of nations now past away; with how much deeper feeling of admiration must we consider those grand monuments of nature which mark the revolutions of the Globe; continents broken into islands; one land produced, another destroyed; the bottom of the ocean become a fertile soil; whole races of animals extinct, and the bones and exuviæ of one class covered with the remains of another, and upon the graves of past generations—the marble or rocky tomb, as it were, of a former animated world; new generations rising, and order and harmony established, and a system of life and beauty produced out of chaos and death; proving the infinite power, wisdom, and goodness of the GREAT CAUSE of all things!"—SIR H. DAVY.

TO THE READER.

THIS work is designed to answer the twofold purpose of a *Hand-book* for the general visitors to the GALLERY OF ORGANIC REMAINS OF THE BRITISH MUSEUM, and an *Explanatory Catalogue* for the scientific observer.

With this view the specimens in each Room are described in a separate chapter, and a *ground-plan* of the Cases, and a *Synopsis* of their contents, are given in the first part or section of each division, to serve as a guide-book for those whose time is limited, and are desirious of obtaining a general idea of the collection.

The palæontologist will, it is hoped, find all the information in these unpretending pages that can reasonably be expected within the prescribed limits of a work of this nature, which is divested as much as possible of technical language to render it acceptable to the unscientific reader, and intended to direct attention to the most important specimens, and invest them with an interest they would not otherwise present to persons unacquainted with this branch of natural knowledge.

My excellent and lamented friend, the late CHARLES KÖNIG, Esq., who for nearly half a century presided over this department of the National Collection, and whose scientific friendship I had the privilege of enjoying from my early years, looked forward with much pleasure to my completion of a task which I should never have attempted, had he not assured me that neither himself nor any other officer of the Museum would undertake it. His sudden death has deprived me of the gratification of inscribing my labours to one so capable of appreciating them, and I can now only offer this unavailing, but sincere tribute of respect to his memory.

In extenuation of any errors or omissions, I would beg to remind the Courteous Reader that the Author is unconnected with the British Museum, and that this volume, like its predecessors, has been composed during the brief and uncertain intervals of arduous professional duties.

G. A. M.

19, CHESTER SQUARE,
Oct. 11, 1851.

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G. A. M.

19, CHESTER SQUARE,
Oct. 11, 1851.

DESCRIPTION OF THE FRONTISPIECE.

(Extracted from Mr. Gould's "Birds of Australia.")

NOTORNIS MANTELLI.

"The acquisition of a new species is always a matter of great interest; but when, as in the present instance, it is of one so nearly extinct as to be only known to us previously by its fossil remains, the interest becomes enhanced in the highest degree. It is well known that the existence of the celebrated *Dodo* is all but traditionary, a fate which, but for Mr. Walter Mantell's fortunate acquisition of a living example, would probably have been shared by the present bird, the characters of which were first made known to us by Professor Owen, from the fossil bones previously discovered and sent home by the talented explorer after whom it is named: those relics are now in the British Museum. (*See* p. 124.)

"That few living examples remain, is evident from the fact that the mounted specimen in Dr. Mantell's possession is the only one that has yet been seen: all the information respecting it that has been obtained is comprised in the account communicated by Dr. Mantell to the Zoological Society of London, and published in their 'Proceedings' for 1850. (*See* p. 126.)

"Upon a cursory view of this bird it might be taken for a gigantic kind of *Porphyrio*, but on examination of its structure it will be found generically distinct. It is allied to *Porphyrio* in the form of its bill, and in its general colouring, and to *Tribonyx* in the structure of its feet, while in the feebleness of its wings, and in the form of the tail, it differs from both. From personal observation of the habits of the two recent genera above named, I may venture to affirm that the habits and economy of the present bird more closely resemble those of the former than of the latter; that it is doubtless of a recluse and extremely shy disposition; that being deprived by the feeble structure of its wings of the power of flight, it was compelled to depend upon its swiftness of foot for the means of evading its natural enemies; and that, as is the case with *Tribonyx*, a person may be in its vicinity for weeks without even catching a glimpse of it. From the thickness of its plumage and the great length of its back-feathers, we may infer that it affects low and humid situations, marshes, the banks of rivers, and the coverts of dripping ferns, so abundant in its native country; like *Porphyrio*, it doubtless enjoyed the power of swimming, but it would seem from the structure of the legs to be more terrestrial in its habits than the members of that genus. I have carefully compared the bill of this bird with that figured by Professor Owen under the name of *Notornis Mantelli*, and have little doubt that they are referable to one and the same species.

"Head, neck, and breast, upper part of the abdomen and flanks, purplish blue; back, rump, upper tail-coverts, lesser wing coverts, and tertiaries, dark olive green, tipped with verditer green; at the nape of the neck a band of rich blue separating the purplish blue of the neck, from the green of the body; wings rich

deep blue, the greater coverts tipped with verditer green, forming crescentic bands when the wing is expanded; tail dark green; lower part of the abdomen, vent, and thighs, dull bluish black; under tail-coverts, white; bill and feet, bright red.

"Total length of the body, 26 inches; bill, from the gape to the tip, $2\frac{1}{8}$; from tip to posterior edge of the plate on the forehead, 3 inches; wing, $8\frac{1}{2}$; tail, $3\frac{1}{2}$; tarsi, $3\frac{1}{2}$; middle toe, 3; nail, $\frac{7}{8}$; hind-toe, $\frac{7}{8}$; nail, $\frac{3}{4}$.[1]

"I cannot conclude these remarks without bearing testimony to the very great importance of the results which have attended the researches of Mr. Walter Mantell, in the various departments of science to which he has turned his attention, nor without expressing a hope that he may yet be enabled to obtain some particulars as to the history of this and the other remarkable birds of the country in which he is resident."

EXPLANATORY.

Plan of the Work.—To ensure the permanent utility of this Hand-Book, a specific notation of the Cases has been adopted in the *ground-plan* of each Room; and to facilitate a reference to any particular cabinet or fossil, so far as the present arrangement of the Gallery of Organic Remains will permit, the letters and numbers affixed to the respective Cases are inserted between brackets, and placed after the letters and figures of the plan; for example, in page 11, letter A refers to the *ground-plan*, and [1, A, B, C,] are the numbers and letters painted on the Wall-case containing the fossil *Algæ*, *Fuci*, &c.

Minerals.—The description of the mineralogical collection is not within the scope of this volume; but for the convenience of the mineralogist who may not possess Mr. König's excellent *Synopsis*, a brief notice of the contents of the Table-cases is inserted.

Fossi Invertebrata.—Of this part of the collection, a very general description only is given, for the objects are too numerous, and too small, to be particularized in a hand-book of this nature. Several of the Table-cases of fossil shells are admirably arranged and named by Mr. Woodward, and cannot fail to prove highly interesting to the Geologist, and instructive to the student in Conchology; to the latter I would commend, in the strongest terms, Mr. Woodward's "*Manual of the Mollusca, or a Rudimentary Treatise on Recent and Fossil Shells,*" *with numerous illustrations,* 1 vol. price 2*s.* published by Weale, as incomparably the best and cheapest introduction to this branch of Natural History in the English language.

Models of Fossils.—Models of some of the most remarkable fossils in the National Collection (a list of which is published in the "*Synopsis of the British Museum*") may be purchased of the *Formatore*.

Casts of the teeth, and of several bones, of the Iguanodon (formerly in my possession) may be obtained of Professor Tennant, 149, Strand.

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[1] The plate accompanying this description represents the Notornis in two positions, of the natural size, and accurately coloured.

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PETRIFACTIONS AND THEIR TEACHINGS;

ILLUSTRATED BY

A VISIT TO THE GALLERY OF ORGANIC REMAINS IN THE BBITISH MUSEUM.

INTRODUCTION.

A DISTINGUISHED Essayist has eloquently and truthfully remarked, that "everything in nature is engaged in writing its own history: the planet and the pebble are attended by their shadows, the rolling rock leaves its furrows on the mountain side, the river its channel in the soil, the animal its bones in the stratum, the fern and the leaf inscribe their modest epitaphs on the coal, the falling drop sculptures its story on the sand and on the stone,—not a footstep on the snow or on the ground, but traces in characters more or less enduring the record of its progress."[1] On the correct interpretation of these autobiographies, inscribed on the rocks and strata by the countless myriads of beings which have successively inhabited the earth, through periods of incalculable antiquity and duration, and whose races are now extinct, is based that most interesting department of natural history which has recently acquired the rank of a distinct branch of modern science, under the title of PALÆONTOLOGY.[2]

As the remains of animals and plants imbedded in the earth are found in different states of preservation, and more or less

[1] Emerson's Essays. *Bohn's Edition.*

[2] From three Greek words, signifying a discourse on ancient beings.

altered in appearance and composition by mineralization, the epithets *figured stones, petrifactions, fossils, organic remains,* &c., are commonly employed to denote the various conditions in which such relics occur. To avoid confusion it is, therefore, necessary to define the sense in which these terms are used in the following pages; especially as the words "petrifactions," and "fossils," are very generally regarded as synonymous, even by well-educated persons.

And here we must premise that the state of preservation of an organic body, and the chemical changes which it may have undergone in the mineral kingdom, have no necessary relation to its antiquity; for in comparatively modern deposits fossil remains of animals and plants often have acquired a stony hardness, while in rocks of the most ancient epochs they are sometimes as little changed as if they had been entombed in the strata but a few centuries.

1. *Fossils,* may be defined as the durable parts of animal and vegetable structures imbedded in rocks and strata by natural causes at a remote period; thus wood in the state of lignite, bog-wood, and coal, or of siliceous or calcareous stone, is *fossil wood;* and bones or shells, whether in an earthy and decaying state, or permeated by calc-spar, flint, or iron, and converted into a hard mineral substance, are alike *fossil bones* or shells.

2. *Petrifactions,* are the remains of animals and vegetables in which the original structure is converted into stone, or, in other words, is *petrified;*[1] such are the silicified stems of trees from Antigua and Germany, and the bones and shells in the Oolitic and Wealden limestones. Such petrifactions may be correctly termed fossil plants, bones, or shells; but similar organic remains, though of equal antiquity, which have not undergone such changes, are not petrifactions in the proper meaning of that term.

3. *Incrustations,* are neither fossils nor petrifactions, but simply durable parts of animals or vegetables invested with

[1] The process by which petrifaction is effected is still involved in obscurity; mineral solutions have permeated the original tissues, and the organic molecules have been replaced by mineral molecules, but how this transmutation is produced is not understood. Mr. Dana's observations and Mr. Jeffery's experiments have, however, elucidated the process of silicification.

travertine or calcareous deposit, which is often compact and of crystalline hardness, but does not permeate the structure of the enclosed substances; such are the so-called petrified eggs, skulls, nests, branches, &c., formed by immersion in the incrusting springs of Derbyshire and other localities.[1]

These preliminary remarks will suffice for our present purpose, and prepare the observer to find many of the fossil shells, corals, bones, &c. in the collection, presenting but little difference in appearance from similar objects collected on the seashore, or from the beds of streams and rivers; while others will be seen to resemble masses of rock, having only the forms of organic bodies. Certain peculiar conditions in which animal and vegetable remains occur will be explained in the course of our investigations, as well as those indications of former beings observable on the surfaces of rocks and slabs of stone, though all vestiges of the original structures have perished.

And here it will be necessary to remind the reader that the objects we are about to examine possess a twofold interest; for they are to be regarded not merely as relics of extraordinary types of animals and vegetables which flourished in the earlier ages of our globe, and have long since become extinct, but also as natural records of the condition of the earth and its inhabitants, affording indications of the extent and duration of the lands and seas, and of climatorial temperature, &c., through vast periods of time, in ages long antecedent to the creation of the existing species and genera, and the establishment of the present order of animated nature.

In contemplating the principal objects that will come under our examination, it will, therefore, be requisite occasionally to refer to the geological characters of the strata in which they were imbedded, and describe the particular locality whence certain fossils were obtained; these digressions will, I trust, increase the interest of our survey, and prove alike attractive and instructive.

The reader who is wholly unacquainted with the principles of Geology should refer to some elementary work on the science, if he would fully comprehend and enjoy the marvellous histories of the past which will be placed before him in the

[1] See "Medals of Creation;" or, "Wonders of Geology," vol. i. p. 75. (6th edit.) for details. Impressions of leaves on travertine are figured in Pict. Atlas, pl. iii. fig. 2.

course of this investigation. As, however, the arrangement adopted in the Gallery is botanical and zoological, not geological, the uninitiated visitor will have no difficulty in understanding the general descriptions of the most important specimens submitted to his notice.

To remind the observer of the relative age and position of the deposits, and the meaning of certain geological terms which we shall sometimes have occasion to employ in the following narrative, a brief table of the British strata[1] is subjoined.

A TABLE OF THE FOSSILIFEROUS DEPOSITS OF GREAT BRITAIN.

MODERN OR HUMAN EPOCH.

ALLUVIAL and VOLCANIC deposits.

POST PLIOCENE OR DILUVIUM.[2]

DRIFT; BOULDER-CLAY, &c.

TERTIARY EPOCHS.

PLIOCENE; the upper and newest Tertiary. (Norwich Crag.)
MIOCENE; or middle Tertiary. (Suffolk Crag.)
EOCENE; the lowermost or most ancient Tertiary. (London, Hants, and Isle of Wight. Paris basin.)

SECONDARY EPOCHS.

CRETACEOUS FORMATION.	Upper Chalk with flints.	South and north Downs of Sussex, Kent and Surrey; Downs of Hants, Wilts, &c.
	Lower Chalk.	
	Chalk marl and firestone; or Upper Green Sand. (Godstone, Undercliff of Isle of Wight.)	
	Galt or blue chalk—marl. (Folkstone.)	
	Green sand.	Shanklin Sands, (Kentish-Rag. Kent. Isle of Wight.)
		Atherfield or Neocomian beds. (Isle of Wight.)
WEALDEN FORMATION.	Weald clay, and Sussex and Petworth marbles.	Wealds of Sussex and Kent, and the South coast of the Isle of Wight.
	Hastings sands and clays.	
	Purbeck strata. (Isle of Purbeck.)	

[1] *Strata* are sedimentary deposits that have been formed in the beds of lakes, rivers, and seas, and have subsequently been displaced and elevated above the water by physical causes. A series, or group of strata, is termed a *formation;* and the fossil remains found in one series or formation differ more or less completely from those of another.

[2] Called also the Quaternary or Diluvian period: these deposits cannot be definitively separated from those of the Modern or Human epoch. The gravel beds near Geneva, which closely resemble the newest tertiary drift in materials and position, abound in bones of animals, almost all of which belong to existing species. See M. Pictet's "*Palæontologie.*"

SECONDARY EPOCHS—(*continued.*)

OOLITIC or JURASSIC FORMATION.	Upper.	Portland beds. (Isle of Portland. Swindon.)
		Kimmeridge clay. (Hartwell, Bucks.)
	Middle.	Coral rag. (Wilts. Gloucestershire, &c.)
		Oxford clay. (Christian Malford. Trowbridge, Wilts.)
	Lower.	Cornbrash. (Wilts. Gloucestershire.)
		Forest marble; Bradford clay. (Bradford, Wilts.)
		Great oolite. (Bath.)
		Inferior oolite. (Cheltenham.)
		Fluvio-marine intercalations. (Scarborough. Stonesfield, Oxfordshire. Collyweston. Brora, Scotland.
LIASSIC FORMATION.		Upper Lias. (Lyme Regis, Dorset.)
		Lias marlstones.
		Lower lias clays, shales, and limestones. (Gloucestershire. Somersetshire.)
TRIASSIC (or NEW RED) FORMATION.		Variegated marls, red sandstones, &c. (Liverpool.)
		Gypseous marls; beds of rock salt.
		Fawn-coloured limestones. (Upper Bunter, and Muschelkalk, of Germany.)

PALÆOZOIC EPOCHS.

PERMIAN FORMATION.[1]		Lower red sandstones.
		Magnesian limestones. (Zeichstein. Lower Bunter, Keuper-Schiefer or Copper Schist of Mansfeld, Germany. County of Durham.
		Marl slates, and brecciated limestones.
CARBONIFEROUS FORMATION.		Coal measures. (The principal depositories of the flora of the Palæozoic epochs.)
		Millstone grits.
		Mountain or carboniferous limestone. (Derbyshire.)
DEVONIAN (or OLD RED) FORMATION.		Red and yellow sandstones and Quartzose conglomerates. (Devonshire. Cornwall. Herefordshire. Forfarshire, &c.)
		Cornstones and marls.
		Tilestones.
SILURIAN FORMATION.	Upper.	Ludlow rocks and Aymestry limestone. (Herefordshire and Shropshire.)
		Wenlock or Dudley limestone.
		Shales.
	Lower.	Caradoc sandstones.
		Llandeilo flags. (Caermarthenshire.)
CUMBRIAN FORMATION.		Slaty rocks with few traces of organic remains. (Cumberland.)

[1] The separation of the strata now termed *Permian* from the Triassic group, with which they were formerly classed, was first proposed by Sir Roderick Murchison, and is based on the fact that the fossils hitherto discovered are entirely distinct from any that occur in the Trias and subsequent formations: it is, therefore, inferred that after the deposition of the so-called Permian strata, a complete change took place in the faunas and floras of the lands and seas, and the Trias is regarded as the dawn of a new system of organic beings.*

* The reader interested in this subject should refer to an able "Monograph on the Permian Fossils of England," by Professor William King, of Queen's College, Galway, recently published by the Palæontographical Society of London; 1850. See also Sir Charles Lyell's "Manual of Elementary Geology," 1851, p. 301.

The subdivisions of the strata are chiefly founded on the differences observable in the faunas and floras—that is to say, in the assemblages of animals and plants which, according to the present state of our knowledge, characterise the respective series of deposits. A few localities are inserted because they will be referred to hereafter. I will only remark that many of the details in the above classification must be considered as arbitrary and provisional; but "hard lines are admissible in Science, whose object is not to imitate Nature, but to interpret her works."[1]

[1] Mr. Greenough.

CHAPTER I.

PART I.

INTRODUCTION—GENERAL DESCRIPTION OF THE GALLERY OF ORGANIC REMAINS—PLAN OF ROOM I.—SYNOPSIS OF CONTENTS OF ROOM I.—FOSSIL VEGETABLES—MINERALS—METEORITES.

INTRODUCTORY.—The extensive and admirably classified Museum of Zoology, presided over by that eminent naturalist, JOHN EDWARD GRAY, Esq., through which the visitor approaches the Gallery of Organic Remains, presents a rich assemblage of the principal types of animated nature which now inhabit the earth, and forms an appropriate and instructive introduction to the suite of apartments, in which are preserved the vestiges of the extinct races of Animals and Plants, that successively tenanted our planet during the innumerable ages which intervened between the earliest dawn of organic existences, and the creation of the human race.

The Gallery of Organic Remains is situated on the north side of the north wing of the Museum, extending from east to west in a suite of six rooms, nearly 400 feet in length by 36 in width. The large specimens are for the most part placed in upright cases affixed to the south wall; and as the rooms are lighted by side-windows, instead of by sky-lights as in the Zoological department, nearly half the wall space is rendered unavailable for cabinets. The complete and excellently arranged Mineralogical Collection is distributed in a series of 60 table-cases, occupying the floors of the Rooms I. to V.; the other tables contain various organic remains, as bones, shells, corals and other zoophytes, echinoderms, &c.

The arrangement of the Fossil Animals and Vegetables is still incomplete: several cases are almost empty, and the con-

tents of others are but provisionally placed. This circumstance has rendered it necessary to introduce an arbitrary notation in the subjoined plans of the rooms which I have drawn up for the present work.

The classification of the Organic Remains is botanical, and zoological; but in consequence of the want of space, and the continual additions which have been made of late years to various departments, the arrangement is necessarily somewhat irregular.

The Fossil Vegetables are placed in Room I., and occupy the wall-cases: the collection commences with the *Cryptogamia*, which are deposited in the cases on the right hand of the entrance, and terminates with the *Conifera*, of which there are examples of large petrified stems in the window-recesses. The wall-surface over the upright cases is for the most part vacant and bare; and the visitor who has previously strolled through the Egyptian Saloon and Gallery, the walls of which are adorned with paintings illustrative of the archæological treasures they contain, will doubtless feel surprise and regret that a suite of rooms devoted to objects of such surpassing interest, and which especially require pictorial illustrations to render them intelligible to the uninstructed observer, and that present a variety of subjects suitable for such decorations, should be suffered to retain their present uninviting and cheerless aspect. If on the walls over the cases in which the coal-plants are placed there were figures of the trees which flourished during the carboniferous epoch,—as for example, the Lepidodendra and Sigillariæ, with their foliage, and fruits, and roots; and above others, representations of Arborescent Ferns, Palms, Conifers, Cycadeæ, &c., how greatly would the pleasure and instruction of a visit to this Gallery of "Organic Remains of a former World," be enhanced! The same observation applies to the other apartments, in each of which there are unoccupied spaces, that at a small cost might be rendered pleasing to the eye, and instructive to the mind, if restored figures of the animals whose remains are in the cabinets, or sections and sketches of the strata and localities whence they were obtained, were painted or suspended on the walls.[1]

[1] This method was adopted in the Author's Museum at Brighton, and proved highly attractive and useful

In Room II. commences the Fossil Fauna; but the assemblage of relics of various classes and orders, provisionally deposited in the cases, forbids a general description. The unique and highly interesting collection of the Fossil Remains of Birds from New Zealand, is the most important feature of this apartment.

Rooms III. and IV. are chiefly appropriated to the Fossil Reptiles. This is indeed a noble collection, unrivalled for its extent and importance: most of the specimens are from various parts of England, and many of them are unique.

The collection of Fossil Fishes constitutes the grand feature of Room V. It is very extensive, and is admirably arranged and named, according to the nomenclature of M. Agassiz. A fine skeleton of the extinct gigantic Elk of Ireland forms a conspicuous object in the centre of this room.

Room VI. The coup d'œil of this part of the Gallery, which is chiefly devoted to Fossil Mammalia, is very imposing. Immediately opposite the entrance is the model of the skeleton of the Megatherium, or colossal Sloth of South America, from Buenos Ayres; and beyond it, the skeleton of the Mastodon of the Ohio, from North America; between them is placed a most extraordinary specimen,—the skull and tusks, (fourteen feet long,) of the *Elephas Ganesa*, from India.

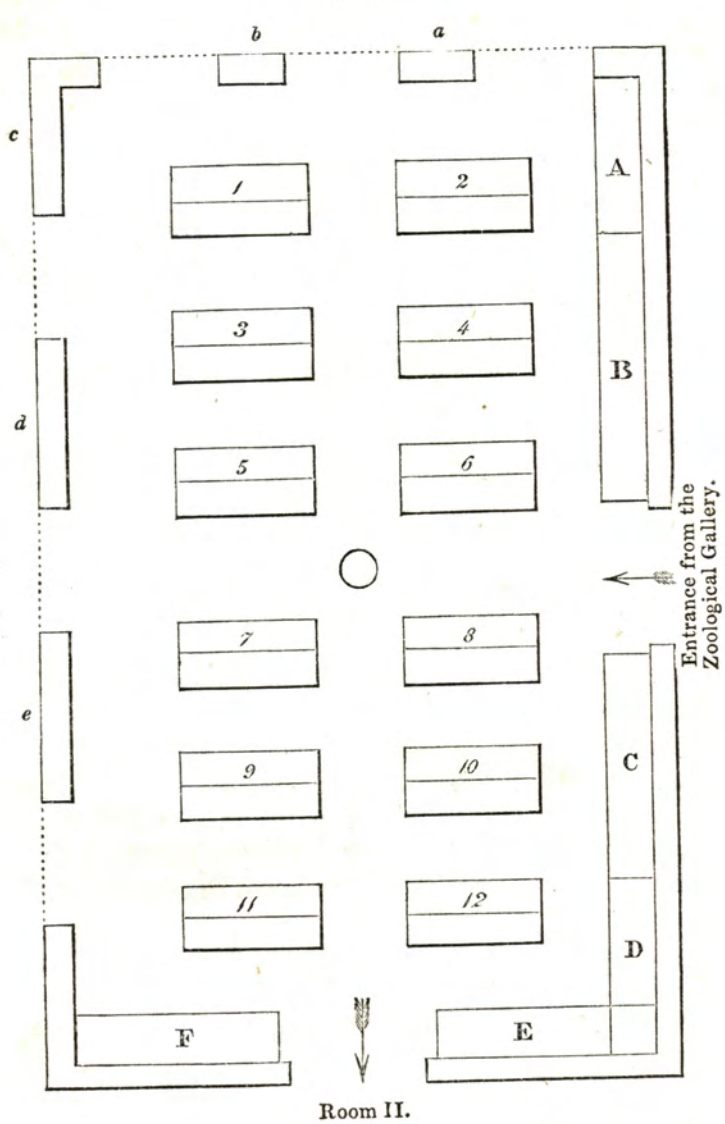
In the wall-cases is an unrivalled series of the crania and jaws and teeth of Mastodons and Elephants of numerous species, in a marvellous state of preservation. They have been cleared from the very compact incrustation which originally surrounded them, with great skill and labour by Mr. Dew. The greater number are from the Sewalik or Sub-Himalayan Mountains of India, and were collected by Major Cautley and Dr. Falconer. Some very fine specimens of the *Mastodon Ohioticus* are from Big-bone Lick, in Kentucky, United States of North America.

This room also contains many choice examples of the crania, teeth, and bones of the Megatherium, Dinotherium, Sivatherium, and other extinct genera of Mammalia; and the celebrated Fossil Human Skeleton in limestone, from Guadaloupe.

With these cursory observations, I would introduce the reader to Room I., requesting him to notice on the lobby, to

PLAN OF ROOM I.

NORTH GALLERY OF THE BRITISH MUSEUM.



the left of the doorway, an admirable model (executed by Mr. Dew, the palæontological modeller and sculptor of the Museum) of the carapace, or shell of a young individual of the extinct Colossal Tortoise of India (*Colossochelys Atlas*), of which there are many fossil remains in the collection. This specimen is ten feet long, twenty-five feet in horizontal circumference, and fifteen feet in girth in a vertical direction; gigantic as are these proportions, they are one-third less than those of the adult original.

ROOM I.

(53 feet long, 36 feet wide.)

Synopsis of Contents.

ORGANIC REMAINS.

Wall-Cases. *Fossil Vegetables.*—Chiefly on the south and west sides of the room. The arrangement is botanical; the simplest forms of vegetable structure, the *Algæ*, &c. are in the first case, to the right of the entrance.

A. [1. A, B, C.] *Algæ and Fuci* (Fossil sea-plants).—With these are several vegetables whose characters are not accurately determined; they belong to a higher group, as *Asterophyllites, Annularia, Pilularites*, &c.

B. [2. B, C, D, E.] On the upper shelves are the *Equisetaceæ*, i.e. plants allied to the *Equisetum*, or Mare's-tail (*Calamites*). On the lower division are *Filicites*, or fossil ferns, of many species and genera.

On the top of this case there are stems of several species of *Calamites*, from the Coal formation.

C. [3. A, B, C, D, E, F.] On the shelves of the upper division are many beautiful specimens of the flattened stems of *Sigillariæ*, and of *Lycopodiaceæ* or Club-mosses, from the Coal strata.

The lower compartment contains numerous species of ferns, in clay-slate or shale, from similar deposits; and others from the Oolite.

The lowermost shelf is devoted to silicified stems of trees allied to the Palms (called *Psaronia* by M. Cotta), many of which are polished in transverse sections, to show the structure.

On the top of this case there are portions of large stems of fossil Palms, from Chemnitz, and from the State of Ohio.

D. [4.] This case is chiefly allotted to the fossil Club-mosses, or *Lycopodites*, some slabs of which are very fine: the fruits of these trees, termed *Lepidostrobus*, are arranged on the lower shelves. There are many fine specimens in ironstone nodules, from Colebrook Dale.

E. [5. A, B, C. D.] The *Sigillariæ* and *Lycopodiaceæ* occupy the upper division; the lower contains fossil plants allied to the *Cycadeaceæ* (labelled *Asphodeleæ*): among these are *Sternbergia;* and *Clathraria, Endogenites*, and *Dracœna*, from the Wealden formations of Sussex and Kent.

On one of the shelves there are a few fruits from the London Clay of the Isle of Sheppey, belonging to plants allied to the Palms (*Nipa*); with leaves and stems of Palms from other localities.

Above cases D and E, are placed a silicified stem of a tree from the Isle of Portland; and several large specimens of *Endogenites erosa*, from the Wealden strata at Hastings.

In the narrow compartment of this case, on the left of the doorway, there is a fine palm-leaf (*Palmacites Lamanonis*), from the Tertiary strata of Aix, in Provence: (formerly in the author's collection).

On the left of the doorway, on the ground, there is part of a petrified stem of a Palm, from the Valley of the Nerbudda, in India.

On the right, a slab of Lias limestone, from Dorsetshire, on which is lying, in relief, a leafless branch, four feet long, of a coniferous tree.

F. [6. A, B, C, D.] The shelves of the upper division contain fossil *Coniferæ* (A and D), and many fine specimens of the vegetables termed *Stigmariæ*, under the general name of *Euphorbiaceæ* (B and C). There are several interesting fossil *Coniferæ*, as *Pinus, Araucaria, Thuytes, Voltzia*, &c.; and fir-cones from the Crag of Norfolk.

The lower division comprises examples of leaves, fruit, and stems, of extinct plants allied to the *Cycadeæ* (*Pterophyllum*)

and *Zamiæ* (*Ctenis*), chiefly from the fluvio-marine strata of the Oolite of Scarborough, in Yorkshire.

In this case are specimens of the extinct Cycadeous plants of the Isle of Portland (named by M. Brongniart, *Mantellia*); and on the top of this case several fine examples, some of which are cut and polished, of similar plants from the same celebrated locality (collected by the author in 1825).

On the lowermost shelves there is an extensive series of silicified trunks of coniferous trees; many are cut transversely and polished, to exhibit the organic structure, which is beautifully preserved.

On brackets between the east windows there are busts of Henry VIII. and of his daughter Mary, sculptured in brown jet.

Meteoric Iron.—On a pedestal between the windows there is a mass of Meteoric Iron from the Gran Chaco, in South America; collected and presented by Sir Woodbine Parish. It weighs 1,400 pounds, and is supposed to be part of that of Otumpa, described by Rubin de Celis, in the *Philosophical Transactions* for 1783.

Small Table Cases, etc.

a. Under the window at the east end of the room. Fine masses of fossil wood from Van Diemen's Land, by Mrs. Howley: some of these are very beautiful examples of opalized wood. In the recesses of the windows there are portions of trunks of trees in a similar state of mineralization, from New Holland; presented by the late Sir Francis Chantry.

b. (*Unoccupied.*)

c. A fine slab of jet, from Whitby.

(The tables of minerals under the windows are not numbered.)

d. A splendid example of the footprints of bipeds, supposed to be those of Birds, (hence named *Ornithichnites,*) on triassic sandstone, from Turner's Falls, Massachusetts, United States of North America. This slab is 8 feet by 6, and contains the foot-tracks of ten or twelve individuals of various sizes, which must have been impressed on the stone when it was in the state of plastic mud, and capable of retaining the imprints of the feet till it became indurated. It was ex-

tracted from the rock with great labour and care by Dr. Deane of Greenfield. In the window recess on the right, there is a slab with two imprints of a colossal biped, the locality of which is unknown.[1]

On the recess of the window between *d* and *e*, there is a large slab with foot-tracks of a supposed reptilian quadruped to which the name of *Chirotherium* has been provisionally given, from the hand-like form of the imprints; in Triassic sandstone, from Storton quarries, near Liverpool. Presented by J. Tomkinson, Esq.

e. Two slabs placed upright in a case affixed to the wall, with footmarks of a similar character. These are from the triassic deposits at Hildburghausen in Saxony.

☞ In the recess of the window, between *c* and *d*, there is a fine mass of the mineral called Subsulphate of Alumina or *Websterite*, from the Plastic clay at Castle Hill, near Newhaven, in Sussex. (Collected and presented by the author. An account of the only known locality of this substance is given in the "Fossils of the South Downs.")

In the centre of the room, at the spot indicated by the circle in the plan, on an elegant table inlaid with choice marbles and minerals, there is a beautifully sculptured tortoise in *Nephrite* or *Jade*. This curious specimen of Indian art was found on the banks of the Jumna, near the city of Allahabad in Hindostan, and brought to England by Lieut.-General Kyd. Presented by Thomas Wilkinson, Esq.

MINERALS.

The mineralogical arrangement adopted by Mr. Konig is that of Berzelius, founded upon the electro-chemical theory and the doctrine of definite proportions. The detail of the arrangement is indicated by the running titles on the outsides of the cases, and the labels attached to the specimens within.[2]

The cases containing the minerals are numbered and arranged in order, the first thirty in the Rooms I. to V. on

[1] These specimens were purchased for 60*l*.

[2] "An electro-chemical arrangement, in accordance with the principles laid down by the great Swedish chemist himself not long before his death, in a memoir on this subject, has been given by Prof. Rammelsberg, in his '*J. J. Berzelius' Neues Mineral System, Nürnberg,*

the south side, and the other thirty in a reversed direction on the opposite side. The affixed numbers are here inserted between brackets.

TABLE CASE 1. [60.] *Organico-chemical minerals—Salts:* Mellite or honey-stone, found in brown coal at Artern in Thuringia, (see Pictorial Atlas of Organic Remains, pl. I. fig. 2.;) oxalate of iron; struvite; *Resins:* amber, of which there are beautiful specimens from Prussia and from the muschel-sandstone of Lemberg in Gallicia, many with insects and portions of vegetables; fossil copal from London Clay, Highgate; Retinasphalt, from Bovey; Idriolite. *Bitumens:* mineral pitch, asphalt and jet; Dapèche; Hatchettine; varieties of coal.

(1.) *Meteorites.*—In this case, and in a small table adjoining, are deposited a very rich collection of native iron and meteorolites. The origin of these substances is so mysterious, as to invest them with a high degree of interest, and I therefore subjoin from Mr. Konig's Synopsis, the following chronological list of those in the Museum whose history is authenticated.

Meteorites or aerolites, *i.e.* stones that fall from the higher regions of the atmosphere, appear to be unquestionably foreign to our planet, and there seems every reason to conclude that these substances originate from small cosmical bodies, having orbital motions through space, and which are occasionally drawn within the sphere of the earth's attraction. Baron Humboldt states that "their direction and enormous velocity of projection render it more than probable that these masses, enveloped in vapours, and reaching the earth in a high state of temperature, are small heavenly bodies which the attraction of our globe has caused to deviate from their previous path. The aspect of these aerolites, and the analogy to minerals contained in the crust of the earth, is very striking. They afford the only experimental knowledge we possess of any of the specific properties or qualities of matter not belonging to our own planet." Meteorites appear to have fallen in the earlier ages of our globe; Sir C. Lyell cites the discovery of a mass of native iron and nickel weighing seventeen pounds, in the auriferous alluvium of Altai, at a depth of thirty feet; and other instances are stated to have been observed in the Carpathian mountains.

2. *Native Iron.*—These masses consist of upwards of 90 per cent. of pure iron, with a small proportion of nickel, copper, cobalt, &c. Native iron, of undoubtedly terrestrial origin, is of very rare occurrence, almost all the insulated masses of this metal hitherto found having proved to be *meteoric;* and of these the following specimens are deposited nearly in the order of their discovery, or of the first mention made of them.

1847,' and will, if circumstances allow it, be hereafter adopted for the collection contained in the Table Cases; the present arrangement remaining nearly as we find it in the 4th ed. of Berzelius' work on the Use of the Blowpipe, published in 1824."—*Mr. Konig's Synopsis.*

A portion of the celebrated mass of iron of the descent of which, at Agram, in Croatia, on the 26th of May, 1751, detailed official accounts were drawn up by the authorities of that place, who presented it to the Roman Emperor, Francis I., and to the Empress Maria Theresa.

Fragment of the iron from the Upper Senegal, in Africa, discovered between the years 1760 and 1770.

A large piece detached from the celebrated mass of Siberian native iron, which was discovered in 1772, by Pallas, on the summit of a mountain between Abakansk and Belskoi Ostrog, on the banks of the Jenisey, where it was considered by the Tartars as a sacred relic: the mass, which originally weighed about 1,680 pounds, is in the Museum of the Imperial Academy of Sciences of St. Petersburg.

Specimens of the native iron from Otumpa, in the Gran Chaco Gualamba, in South America, found, in 1783, by Don Rubin de Celis, who estimated the weight of the mass to be about 300 quintals, or 15 tons.

A large specimen of the Brazilian iron, found at the Bemdegó rivulet, Capitania of Bahia, in 1784, described in 1816.

Some of the Mexican meteoric iron supposed to be from that of Xiquipilco, first brought into notice in 1784.

A large piece (presented by John Parkinson, Esq.) of the iron of Zacatecas, Mexico, known time out of mind, but first described in 1792; and a small one of that found in the province of Durango, described by Baron Alexander von Humboldt (this has by some been confounded with that of the preceding locality).

Two pieces of the Cape meteoric iron, found in 1793, and first made known in Barrow's Travels in Southern Africa: the mass is now in the cabinet of Haarlem.

A portion of the mass, originally weighing upwards of 3,300 pounds, found at Bitburg, in the Eifel, N. of Treves, in 1805, but which, from ignorance, was committed to the smelting furnace.

A portion of the mass from Texas (Red River), found 1808, described 1845.

Three specimens of iron from Rasgata, N.E. of Santa Fé de Bogota, South America; found in 1810, and described about twenty-four years afterwards.

A piece from the large mass (originally weighing 191 pounds, of which upwards of two-thirds came to the Imperial Collection at Vienna) of the iron of Elbogen, near Carlsbad in Bohemia, where from time immemorial it had been known by the popular and legendary appellation of the Enchanted Burgrave (der verwünschte Burggraf); its meteoric origin ascertained in 1811.

Small portions of the meteoric iron from Texas, known to the scientific world since 1814.

Two specimens of the mass of iron found at Lenarto in Hungary, in 1814, one of which, being polished and treated with acid, exhibits the outlines of imperfect crystals.[1]

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[1] The delineations thus produced are known by the appellation of Widmannsted figures.

A mass of iron from Lockport, New York; found in 1818, described in 1845.

A specimen of the iron from Burlington, in the Otsego County, New York, found in 1819.

An Esquimaux knife and harpoon (from Davis's Straits, Lat. 76° 12′ N., Long. 53°) the iron of which is meteoric (mentioned in Capt. Ross's voyage, 1819, and presented by the Lords Commissioners of the Admiralty).

Small portions of the iron from Guildford County, North Carolina, discovered in 1820.

A mass of iron from the province of Atacama, republic of Bolivia, resembling that of Siberia, and, like it, containing much of an olivine-like substance within its cells; described in 1827, and presented by Sir Woodbine Parish.

A mass from the N.E. corner of Walker County, Alabama, found in 1832.

A specimen of the iron which was seen to fall, July 31st, 1835, in Dickson County, Tennessee.

A portion of that of Ashville, Buncombe County, N. Carolina, found and described in 1839.

A ponderous piece of iron from Crosby's Creek, in the S. W. part of Cocke County, Tennessee, found 1839 (with this is placed a mass of graphite found in it, weighing 830 grains).

A smaller piece from Greenville, Green County, Tennessee, found in 1842.

The greater part of the mass of iron found in the Sevier County, Tennessee, in 1840.

Three characteristic specimens, one containing much graphite, of the iron from Arva, in Hungary, discovered in 1843.

A polished piece of the iron found in the Otsego County, New York, in 1845.

Mass of iron from Smithland, Livingston County, Kentucky, found in the same year.

A considerable portion of the mass of iron, weighing 280 pounds, found in the same year at Carthage, Smith County, Tennessee; as was that of Hommoney Creek, near the base of Pisgah Mountain, Buncombe County, North Carolina.

A portion of the iron ploughed up about seven miles from Chesterville, Chester County, S. Carolina, described 1849.

Another of that which was seen to fall at Braunau, in Bohemia, July 14th, 1847.

A portion of that found in the same year near Lake Læsgen, in Brandenburg.

Also, the greater portion of the mass discovered at the close of the same year near Murfreesboro', Rutherford County, Tennessee.

Of *Meteoric stones*, or *Meteorites*, (classed with native iron, because they all contain this metal, generally alloyed with nickel,) the following are placed in chronological order :—

Case 1*.—A large fragment of the stone which fell at Ensisheim, in

Alsace, Nov. 7th, 1492, when the Emperor Maximilian, then King of the Romans, was on the point of engaging with the French army; this mass, which weighed 270 pounds, was preserved in the cathedral of Ensisheim till the beginning of the French Revolution, when it was conveyed to the public library of Colmar.

Meteoric stone which fell at Reichstadt, in Bohemia, June 22d, 1723.

One of the stones which fell, July 3d, 1753, at Plan, in the circle of Bechin, Bohemia, and which contains a great proportion of attractable iron.

Portion of a stone which fell at Maurkirchen, in Bavaria, Nov. 20th, 1768.

A meteorite which fell at Bobric, government of Charkow, Ucraine, Oct. 1st, 1787.

Specimens of those that were seen to fall at Barbotan, at Roquefort, and at Juliac, in the Landes of Gascony, July 24th, 1790.

One of a dozen stones, of various weights and dimensions, that fell at Sienna in Tuscany, June 16th, 1794.

The *meteoric stone, weighing* 56 *pounds,* which fell near Wold Cottage, in the parish of Thwing, East Riding, Yorkshire, Dec. 13th, 1795.

Fragment of a stone of 20 pounds, which fell in the commune of Sales, near Villefranche, in the department of the Rhône, March 12th, 1798.

Specimens of stones that fell near the city of Benares, in the East Indies, Dec. 19th, 1798; presented by Sir Joseph Banks and W. Marsden, Esq.

Entire and broken specimens of the meteoric stones of which a shower was seen to descend at Aigle, in the department of the Orne, April 26th, 1803.

Meteorite which fell at Possil, near Glasgow, April 5th, 1804.

Fragment of that which fell, June 27th, 1807, near Timochin, Smolensk, Russia.

Fragment of one of those that were seen to fall at Weston, in Connecticut, Dec. 14th, 1807.

Fragment of one of several meteorites that fell, April 19th, 1808, at Casignano, near Borgo St. Domino, in the Duchy of Parma.

Two of the meteorites with shining black surfaces, fallen, May 22d, 1808, at Stannern, in Moravia; one of them presented by H.I.M. the Emperor of Austria.

Two fragments of the Tipperary meteorite which fell in August, 1810; it contains quartz globules of a green colour, owing to oxide of nickel.

A fragment from one of those of Berlanguillas, in Catalonia, July 8th, 1811.

A fragment of one weighing 66 pounds, which fell, August 5th, 1812, near Chantonnay, between Nantes and La Rochelle, Department of the Vendée.

Fragment of the meteoric stone which fell at Adare, in the county of Limerick, Ireland, September 10th, 1813.

Fragment of the stone which fell, in March 1814, in the vicinity of Wiburg, in Russian Finland.

Fragment of one of those which fell, Sept. 5th. 1814, at Agen, in the Pyrenees.

A portion of the meteorite of Chassigny, near Langres, Dep. of the Upper Marne, which fell on the 3d of October, 1815.

One of those that descended at Jonsac, in the Department of the Lower Charente, the 13th of June, 1819.

Fragment of the largest of those that fell at Juvénas, Dep. of the Ardèche, 15th of June, 1821.

A portion of the meteorite which descended at Nanjenoy, in Maryland, February 10th, 1825, formerly in the possession of the Author, to whom it was presented by Professor Silliman.

Fragment of one of the meteorites which fell, May 9th, 1827, at Drake's Creek, Nashville, Tennessee.

Another of that of Richmond, Chesterfield County, Virginia, observed to fall June 4th, 1828.

Another which was seen to fall at Aldsworth, 12 miles E. of Cirencester, August 4th, 1835.

A meteorite, weighing about four pounds, which fell at the village of Akburpoor, in the district of Saharanpore, April 18th, 1838; presented by Major Cautley, Bengal Artillery.

A fragment detached from one of the three stones which, on June 6th, 1838, simultaneously fell at three villages, about a mile distant from each other, in the valley of Berar (situated Lat. 21° N., Long. 77° 20′ E.), in the East Indies.

Two of those that were seen to fall, October 13th of the same year, at Old Bokkeveld, at the Cape of Good Hope; the larger presented by Sir John Herschel, Bart., the smaller by E. Charlesworth, Esq.

A fragment of that which fell at Little Piney, Missouri, February 13th, 1839.

Two large portions of the stone that fell, June 12th, 1841, at Triguerre, Canton of Chateau-Rénard, Department of the Loire.

A large fragment of the remarkable meteoric stone that fell at Bishopville, S. Carolina, in March, 1846, and another of that which descended February 25th, 1847, near Marion, in Linn County, State of Iowa, North America, and of which an account has been published in a late number of Silliman's American Journal.—*Mr. Konig's Synopsis.*

3. [59.]—Contains the chlorides: viz. chloride of sodium, ammonium, lead, copper, silver, mercury, &c.

4. [2.] Native silver, of which there are some very rich and beautiful forms; native mercury, platinum, &c.; palladium and osmiridium in a wrought state; irite from the Ural Mountains.

5. [58.] Fluorides; fluor spar; chlorophane; fluoride of calcium, yttrium, and cerium.

[58 A.] Silicates containing fluorine. Saxon, Brazilian, and Siberian topazes, some imbedded in rock crystal; pyrophysalite from Fahlun in Sweden; choridrodite from New Jersey.

6. [3.] Native gold, pure and alloyed; electrum from Schlangenberg in Siberia.

"In this case (continued to case 12 of the minor notation) begin the electro-negative metallic substances called metalloids, and their non-oxidized combinations."—*Mr. Konig's Synopsis.*

Tellurium and tellurets; native antimony; antimonial silver.

7. [57.] Various phosphates. Phosphate of iron, manganese, copper,

yttria, and phosphates of alumina, as wavellite, arurite, the *calaite* or real turquois from Persia,[1] &c.

[57 A.] Phosphates combined with chlorides. Pyromorphite; arseniates of lead, &c.

[57 B.] Phosphate of lime combined with chloride of calcium. Rare crystallizations of *apatite*. Chloro-carbonate of lead. The unique suite of crystals is from Cromford Level, near Matlock Dale, Derbyshire.

8. [4.] Native arsenic, with nickel and with cobalt. In the opposite half of this case, substances belonging to the orders carbon and selenium. Diamonds; several illustrations of the various crystalline forms of this pure state of carbon; diamonds imbedded in siliceous breccia, in compact brown ironstone; and a specimen of the alluvial rock called *cascalhao*, in which diamonds occur in the East Indies and the Brazils. Anthracite. Graphite. Seleniurets of lead, copper, mercury, cobalt, &c. Sulphur from the Lipari Isles. A medallion in selenium of Berzelius, the discoverer of this metal.

9. [56.] Arsenious acid, and arseniates of lime, iron, copper, cobalt, nickel, &c.

10. [5.] Splendid crystallisations of sulphur from La Catolica in Sicily. These are succeeded by the sulphurets, which occupy half of this, and seven of the next following table cases, according to the museum notation. Sulphuret of manganese, zinc or blend, &c.

11. [55.] Sulphates of magnesia, zinc, iron, copper, lead, &c. Sulphate of uranium, oxide or johannite, very rare, from Bohemia. Sulphates of alumina. Websterite from Sussex and Halle. Beautiful series of examples of lazurite or *lapis lazuli*.

12. [6.] Sulphurets of iron, or iron pyrites. Sulphuret of cobalt, of nickel, of cadmium, &c.

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[1] The oriental turquois is an hydrate of aluminum coloured by oxide of copper and iron; it is found in amorphous masses in alluvial clay, and in irregular veins in flinty slate, in Persia and Siberia. The common or accidental turquois is fossil ivory or bone stained by blue phosphate of iron or carbonate of copper.

CHAPTER I.

PART II.—FOSSIL VEGETABLES.

FOSSIL VEGETABLES—PETRIFIED VEGETABLES—CARBONIZED VEGETABLES—COAL—AMBER — JET — DIAMOND — FUCOIDES— ASTEROPHYLLITES—EQUISETACEÆ — CALAMITES — FILICITES — SIGILLARIA — STIGMARIA — ERECT SIGILLARIA — LYCOPODIACEÆ — LEPIDODENDRON—CARBONIFEROUS FLORA — PSAROLITES—CLATHRARIA—ENDOGENITES—DRACÆNA—FOSSIL PALMS—NIPATITES — CONIFERÆ — CYCADEACEÆ — ZAMIÆ—PETRIFIED FOREST OF PORTLAND — MANTELLIA—FOSSIL TREES OF NEW HOLLAND.

FOSSIL VEGETABLES. — Vegetable remains occur in the mineral kingdom in various states of preservation, and under very different conditions; in some cases, they are but little changed in aspect and composition; in others, they are so completely metamorphosed that their vegetable nature can only be detected by the aid of the microscope. It will suffice for our present purpose to consider two principal states in which the fossil remains of trees and plants are preserved.

1st. *Petrified Vegetables:* In this state the organic structure is permeated by mineral matter, and oftentimes the original vascular tissues are transmuted into stone: it may be calcareous, as in some of the fossil woods from the Lias; or siliceous, as in the wood from New Holland, and the palm-stems from Saxony; or partly calcareous and partly siliceous, as the trees from the Isle of Portland, &c. Iron is a frequent constituent in the petrifaction of vegetable substances; and the sulphuret, or iron pyrites, is very constantly present in wood, fruits, leaves, &c., imbedded in argillaceous deposits; often imparting a most beautiful metallic lustre to the organic structures, as in the fossil fruits from the Isle of Sheppey.

2d. *Carbonized Vegetables:* The other state in which vegetable substances are found is that of carbonization—that peculiar transmutation which dead vegetable structures undergo when buried in the earth, and subjected to heat and moisture: a specific fermentation or putrefaction (the bituminous) then takes place, and either bog-wood, lignite, brown coal, jet, or true mineral coal, containing combustible oils, is the result, accordingly as the necessary conditions are more or less perfectly fulfilled; for the formation of coal appears to depend on the engulfing of large quantities of recent vegetable substances beneath deposits of clay, mud, silt, and sand, which shall exclude the air, and prevent the escape of the gaseous elements, when released by decomposition from their organic combination. Such has been the origin of the immense accumulations of fossil fuel, or coal, in various parts of the world; and of the delicate fern-leaves and other foliage, which appear as pellicles or films of carbonaceous matter adherent to the surfaces of the slabs of slate and stone in the cases A, and B, before us: these are the leaves of vegetables converted into carbon or charcoal; some of these leaves even retain their flexibility, and may be removed from the surface, like the specimens in a hortus siccus.

Coal.—But though the vegetable origin of all coal is unquestionable, yet evidence of the original structure of the plants or trees whence it was derived is not always attainable. The most perfect coal seems to have undergone a complete liquefaction, and if any portions of the vegetable tissues remain, they appear as if imbedded in a bituminous mass. The slaty coal generally preserves traces of cellular or vascular tissue, and the spiral vessels and dotted cells of coniferous trees may often be detected by the microscope. In many instances the cells are filled with an amber-coloured resinous substance; in others the organization is so well preserved, that on the surface of a block of coal cracked by heat, the dotted glands may be observed. Some beds of coal are wholly composed of minute leaves or disintegrated foliage, and if a mass recently extracted from the mine be split asunder, the exposed surfaces will be found covered with delicate laminæ of carbonized leaves and fibres matted together, and flake after flake may be peeled off through a thickness of many inches.

Rarely are any large trunks or branches of trees observable in the beds of coal; the general appearance of the carboniferous mass is that of an immense deposit of delicate foliage which has been shed and accumulated in a forest, and consolidated by great pressure, while undergoing that peculiar process by which vegetable matter is converted into carbon. In fine, a gradual transition may be traced from the peat-wood and submerged forests of modern times, in which leaves, fruits, and trunks of indigenous trees are preserved, to those vast deposits of mineral coal, formed by the bitumination of the now extinct plants and trees of the floras which flourished in the earlier ages of the globe.

AMBER, JET, DIAMOND. — *Table-cases* 1, *and* 8.—Before describing the fossil plants whose stems, foliage, and fruit, are displayed in the wall-cases of this room, we must direct attention to the table-cases that contain a fine suite of specimens of Amber [60], Jet, and Diamond 8, [4], for these substances are unquestionably of vegetable origin.

Amber, so remarkable for its electrical properties, and so much in request for ornamental purposes, is a fossil resin, the product of an extinct species of pine (*Pinus succinifer*), most nearly allied to *Pinus abies*, and *P. picea*, but essentially distinct. The Amber in the European markets is principally collected from the shores of the Baltic, between Memel and Konigsberg, being washed out of submerged beds of lignite, and thrown up on the strand by the waves. Amber is occasionally found on the eastern and northern shores of England. The forests of Amber-pines appear to have been situated in the south-eastern part of what is now the bed of the Baltic, in about 55° north latitude, and 37° to 38° east longitude, and were probably destroyed at the commencement of the diluvial period. Insects, spiders, small crustaceans, leaves, and fragments of vegetable tissue, are often imbedded in amber; and a few hairs and feathers of mammalia and birds have been detected: these organic bodies must have become immersed in this substance when it exuded from the trees in a soft or viscid state, for they are often preserved as fresh and beautiful as if recently embalmed in the liquid resin. Upwards of 800 species of insects have been discovered, chiefly Aptera, Diptera, Neuroptera, Coleoptera, Libellula, &c.; by far the greater part belong to extinct forms.

The vegetable remains comprise four species of pine, and species of cedar, cypress, juniper, yew; and of oak, poplar, beech, ash, &c.; and a few ferns, mosses, liverworts, confervæ, and fungi. The amber appears to have chiefly exuded from the root-stock, but also from the bark and the wood, as is the case with the *Copal* and *Animé*, which are resinous substances obtained from certain trees in India and America, and largely employed for varnish: these resins are often substituted for true amber, especially when they contain insects, &c.; but these are always of the existing indigenous species of the country. There are many examples of copal and animé, containing insects, placed in the case with genuine fossil amber, for comparison. The difference observable in the colour of the various species of amber, is attributable to accidental chemical admixtures.

Jet.—This substance is so evidently wood in a carbonized state (many species showing coniferous structure), that it is only necessary to direct attention to the specimens in Case 1. Some of the most productive beds of this fossil in England are those in the Lias shale, near Whitby, in Yorkshire.

In this case there is an interesting example of Hessian brown lignite passing into bituminous coal.

Diamond.—In Case 8 [4] there are many varieties of the precious gem—the diamond—illustrating its varied colours and crystalline forms; among these are diamonds imbedded in siliceous breccia, and in brown ironstone, and an octahedral crystal with alluvial gold; and models of some of the largest diamonds. The diamond, as is now generally known, is nothing more than carbon or charcoal in a pure crystalline state; of its vegetable origin there is no doubt. At a heat less than the melting point of silver it burns and is volatilized, yielding the same elementary products as charcoal. By voltaic action it has been converted (by Jacquelin, Faraday, Gassiott) into a substance possessing the appearance, physical characters, and electrical properties of coke or graphite, losing its insulating power, and becoming a conductor: its ordinary specific gravity is 3.368; when changed into coke, 2.679. The diamond, like amber, is probably a vegetable secretion, and has acquired its crystalline structure by electro-chemical action. In Southern India and in the

Brazils diamonds occur in breccia, composed of quartzose and opaline pebbles, united by an arenaceous ferruginous cement; in Bundel Kaand, in sandstone, supposed to belong to the Triassic deposits, for there are strata of that age 400 feet in thickness beneath the lowest diamond beds, and indications of coal underlying the whole.[1]

ALGÆ, FUCI, &c.—*Case A.*—Remains of several kinds of vegetables of the simplest structure, as Fuci, Algæ, Fungi,

LIGN 1.—FOSSIL FUCUS IN MALM-ROCK, BIGNOR, SUSSEX.
Fucoides Targionii.
(NAT. SIZE.)

&c., occur in a fossil state, and even some minute parasitical species have been detected on the leaves of fern in coal shale.

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[1] See "Wonders of Geology," 6th edit. pp. 703—706, for an account of Amber, Diamond, Bitumen, Petroleum, Anthracite, Plumbago, &c.; "Medals of Creation," vol i. p. 83.

A most important acquisition has very recently been made to the Cabinet of Diamonds; an unique series of crystallized specimens, purchased of Professor Tennant, comprising upwards of sixty examples of rare modifications of form, and of various colours. It formed part of the celebrated cabinet of precious stones formed with great taste and judgment, and regardless of expense, by the late Henry Phillip Hope, Esq. Of the cubic crystal there are six; of the octohedron, sixteen or eighteen; of the hemitrope, or macled crystals, four; of grouped crystals, thirty. This most interesting suite of gems includes also several fine specimens of what are termed "diamonds of nature," which are diverging fibrous concretions of this crystalline substance. A model of the matchless Indian diamond, known as the *Koh-i-noor*, or Mountain of Light, and now exposed to public view in the Great Exhibition, by Her Majesty's gracious permission, will shortly be added to this unrivalled collection.

The case, *A*, contains several species of Algæ and Fuci, and many fossil plants belonging to a higher class, but whose natural affinities are not accurately determined. Much of the space is occupied by fossil ferns, and specimens of a common and elegant tribe of coal-plants (named *Asterophyllites*, *Annularia*, &c.), whose verticillate foliage is too remarkable to escape notice, and is often seen on the slabs of coal-shale associated with ferns.

Fucoides. Of fossil fuci there are specimens from Bignor, in Sussex, of a species peculiar to the firestone of the chalk formation,—the *Fucoides* (*Chondrites*) *Targionii;* and an elegant species named *Fucoides arcuatus.* With the fucoides are specimens of fossil algæ, labelled *Spherococcites*, which are sea-weeds with thick membranous and coriaceous fronds, divided into digitated lobes, wide or narrow, often irregular and elongated, without nervures, and with a smooth surface, bearing irregular tubercles; from the Oolite of Solenhofen.

On the shelves there are pieces of ironstone with vestiges of carbonized vegetables, from the Wealden (of Heathfield, Sussex), some of which are probably referable to fresh-water aquatic plants; others to trees allied to the yew or cypress (*Thuyites*).

Asterophyllites.[1]—*Case A.*—The specimens of elegant foliage on slabs of coal-shale, labelled *Asterophyllites*, *Annularia*, and *Sphenophyllum*, belong to a tribe of extinct dicotyledonous plants, which, like the existing Cycadeæ, had their seeds exposed; hence the name of the order, *Gymnosperms*, or naked seeds.

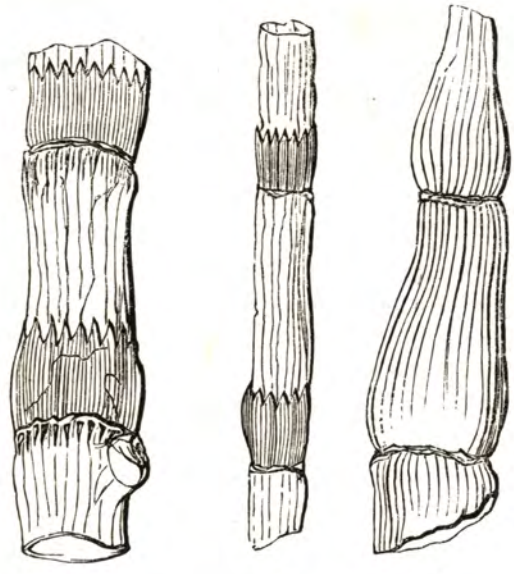
The *Asterophyllites*, so named from the star-like disposition of their foliage, had branched articulated stems, with verticillate leaves arranged perpendicularly to the branches which supported them; but as the foliage is in most examples partially imbedded and concealed in the stone, the natural appearance of the plant is but seldom observable. The fossils known as *Volkmannia* are now ascertained to be Asterophyllites in fructification.

The *Annularia* were herbaceous plants, with verticillate foliage, like the former; but the whorls were arranged on

[1] Figured in "Medals of Creation," p. 152; and "Wonders of Geology," 6th edit. p. 717.

the same plane with the stems whence they proceeded, and, in consequence, their remains present a very elegant appearance when expanded on the schist. Each whorl is composed of from twenty to thirty linear lanceolate leaves, which are united at their base, so as to form a zone around the stem: it is supposed that they were aquatic, or marsh plants, the stems and leaves floating on the surface of the water.[1] Both these extinct types of plants are common in the carboniferous strata.[2]

LIGN. 2.—ANNULARIA: IN COAL-SHALE. ($\frac{1}{2}$ *nat. size.*)



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LIGN. 3.—EQUISETUM LYELLII. POUNCEFORD.

Fig. 1. Stem with two sheaths, and a head at the lowermost joint.
2. Stem of a young plant, pyritified.
3. Stem with the cryptogamous head. (*Nat. size.*)

EQUISETACEÆ.—*Case A.*—Fossil plants allied to the Equisetum (Mare's-tail). The family of the Equisetaceæ comprises

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[1] See "Tableau des Genres de Végétaux Fossiles." Par M. Adolphe Brongniart. Paris, 1849.

[2] Plate V. of "Pictorial Atlas of Organic Remains" contains coloured figures of both genera.

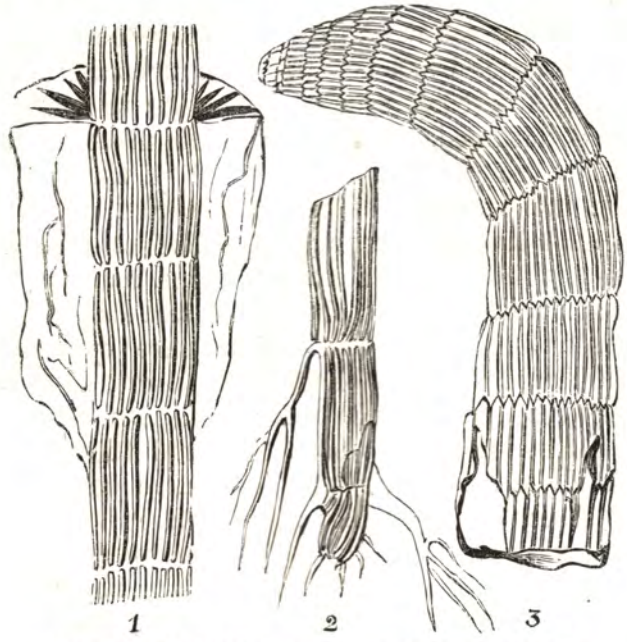
but one genus, the common species of which (*Eq. fluviatile*) abounds in marshy tracts, and on the banks of our ditches and rivers. It has a jointed stalk, encircled by elegant cylindrical dentated sheaths, and garnished with verticillate linear leaves. In a fossil state several species of this genus are known, of which there are specimens in Case A. Those of the *Equisetum Lyellii*, from Pounceford in Sussex, were collected by the Author in 1825. This species is peculiar to the Wealden deposits; it has a cylindrical and articulated stem, the articulations of which are embraced by regularly dentated sheaths. It was a slender elegant plant, of the proportions of the common existing Mare's-tail.[1]

Equisetites.—*Case B.*—These are the stems of gigantic equisetaceous plants, which, though allied by their general characters to the diminutive existing Equisetum, differ in some essential particulars. They are named by M. Brongniart, the eminent botanist, *Equisetites*. These stems are from twenty to thirty feet in height, and from ten to fourteen inches in diameter. The surface is smooth, not striated, and is not impressed by the denticulations of the sheath, as in the Mare's-tail. The fructification is unknown. These plants, of which there are many specimens in Case B. (of *Eq. columnare*, *Eq. laterale*, &c.), are common in the inferior oolite of Yorkshire, and are frequently discovered in an upright position. Extensive areas covered by the roots and erect stems, apparently occupying the spots where they originally grew, have been laid bare in the Cleveland Hills. A few freshwater bivalves are the only fossil-shells observed in the laminated sandstone in which the stems are imbedded.

Calamites.—*Case B, Upper Shelves.*—These large stems belong to a tribe of plants which abounded in the carboniferous epoch, and must have constituted an important feature in its flora, for their remains are abundant in the coal deposits of every country. Though bearing a general resemblance to the Equisetaceæ, they are entirely distinct; their stems are articulated and regularly striated, and sometimes arborescent; the articulations are in general marked with annular depressions, and studded with tubercles; in

[1] Pounceford, near Burwash, in Sussex, is an interesting locality of the Wealden. See "Geology of the South-East of England," p. 221.

some examples, there are remains of a stellate sheath encircling the joints, but this is altogether different from the



LIGN. 4.—CALAMITES, FROM THE COAL FORMATION.
Fig. 1. Calamites radiatus. ($\frac{1}{2}$ *nat. size.*)
2. Stem with roots. ($\frac{1}{2}$ *nat. size.*)
3. Calamites approximatus. ($\frac{1}{5}$ *nat. size.*)

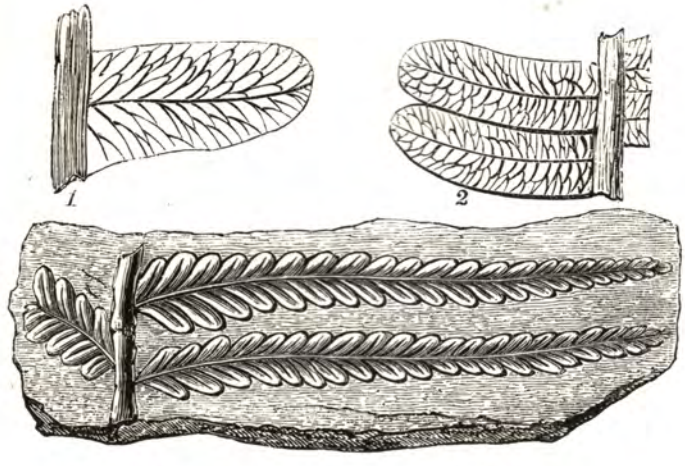
cylindrical sheath of the Equisetaceæ. The stems often attain a height of forty or fifty feet, and a diameter of from one to three feet. When specimens are lying in the same plane with the lines of stratification, they are generally pressed flat; but when found in an erect position, they retain their natural cylindrical form. The bark, in the state of a carbonaceous crust, frequently invests the stem; but I have not been able to detect any traces of internal structure. The axis of the stem appears to have perished, and its place is occupied by clay or sand. Vestiges of the roots are sometimes preserved.[1] The case comprises several species: as *Calamites approximatus, C. canniformis, C. nodosus, C. decoratus,* &c.

[1] Specimens are figured in "Medals of Creation," p. 110; and seven species in "Pictorial Atlas of Organic Remains," Pl. XIII.—XVII. p. 43.

FILICITES, OR FOSSIL FERNS.—*Cases A. B. C.* [1, 2, 3.]—This numerous and interesting tribe of vascular cryptogamous plants, the living species of which confer a peculiar elegance on the flora of the countries in which they abound, prevailed in great numbers and variety during the carboniferous period; several hundred extinct species, belonging to many genera, have been determined. Ferns are distinguished from other vegetables by the peculiar arrangement of the veins of the fronds, and the development, in most species, of the fructification on their leaves. Although the largest British species scarcely exceeds four or five feet in height, many of the tribe peculiar to hot climates are arborescent, and attain an altitude of thirty or forty feet; their stems are cylindrical and without branches, and the foliage spreads out from the summit of the tree and expands into an elegant canopy. The leaves on the stems are not persistent, and the petioles soon become detached from their base, and leave permanent cicatrices, or scars, on the trunk; and these imprints are so durable, and so symmetrically arranged, as to afford characters by which the stem of a tree-fern may easily be recognised in a fossil state; for though the stem may be pressed quite flat, and its foliage entirely wanting, the configuration and disposition of the scars afford a certain means of identification. The leaves are characterised by the form, regularity, and peculiar mode of subdivision of the segments, and by the delicacy, evenness, and distribution of the veins or nervures. From the elegance and diversity of form of the foliage, fossil ferns are the most remarkable and attractive vegetable remains in the ancient strata; and in the collection before us, a considerable number of the most important and characteristic species are exhibited. The greater part are from the coal deposits, the fern-leaves generally occurring in the schists or shales that form the roof of the beds of coal.[1] Many of the strata of shale are made up of carbonized fern-leaves and stems closely pressed together. The roof of a coal mine, when newly exposed, often presents the most interesting appearance from the abundance and variety of leaves, branches, and stems, that appear sometimes in relief, sometimes im-

[1] See "Wonders of Geology," Sixth Edition, pp. 666—677: "On the nature of Coal Deposits."

pressed, on the dark shining surface. When the shale or stone is of a light colour, the contrast of the black carbonized foliage increases the striking effect of these subterranean floras of the ancient world. The specimens in coal-shale exhibited in Cases *B* and *C*, are for the most part from the coal-shales of Great Britain; the series comprises a considerable number of the genera, and many of the species that have been identified by M. Brongniart, Sternberg, Lindley, Hutton, and other eminent botanists. (Pecopteris, Pachypteris, Sphenopteris, Cyclopteris, Neuropteris, Glossopteris, Odontopteris, Phlebopteris, &c.[1])



LIGN. 5.—LONCHOPTERIS MANTELLI. WEALDEN.
Figs. 1 and 2. Leaflets magnified to show the venation.

FERNS of the WEALDEN.—*Case B.*—There are here specimens of two species of fern which require especial notice, because they were obtained from the ancient freshwater deposits of the south-east of England—the Wealden—associated with the reptilian remains of which we shall have occasion to treat hereafter.

Lonchopteris.—One of these, named Lonchopteris (*L. Mantelli*), from the spear-shaped fronds, is characterised by the peculiar reticulation of the venation. There are three fossil

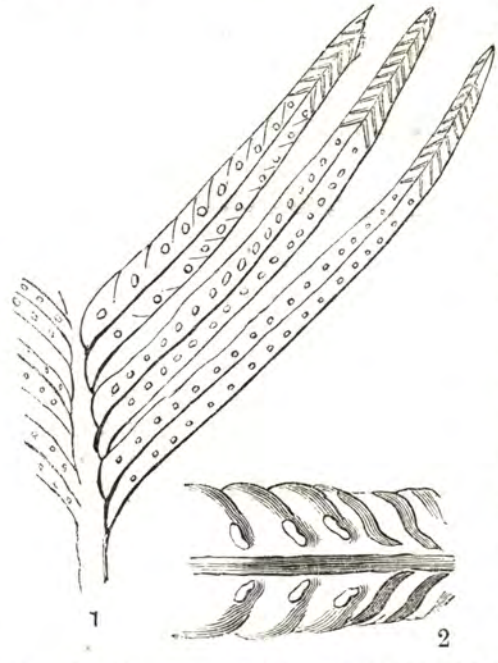
[1] See "Medals of Creation," vol i. pp. 113—124, for figures and descriptions of these genera of fossil ferns. Several kinds are represented in the "Pictorial Atlas," pp. 4, and 28—32 inclusive.

LIGN. 6.—SPHENOPTERIS MANTELLI. WEALDEN. (*Natural size.*)

species of this genus, and these resemble the living ferns of the genera Lonchitis and Woodwardia ; two occur in the Coal deposits ; the other, the one under consideration, in the Wealden and Greensand. The latter appears to have been a delicate plant, for though vestiges of the carbonized foliage are very generally distributed through the Wealden deposits, it is rarely that any considerable portion of a frond can be obtained.

Sphenopteris.—The other characteristic Wealden plant is the Sphenopteris (*S. Mantelli*), or wedge-leaf fern, remarkable for its elegant and simple fronds, as shown in the annexed figure. (*Lign.* 6.)

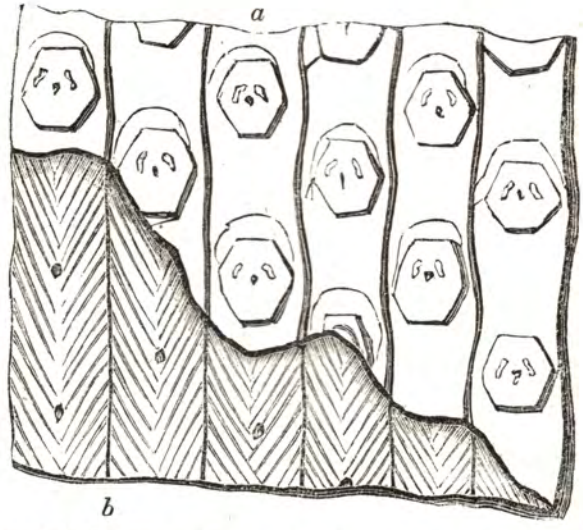
ANOMOPTERIS MOUGEOTTI.—*Case B.*—On the front of one of the middle shelves, on a block of fawn-coloured sandstone, are remains of the foliage of a large species of fern, labelled as above. These fossil leaves are remarkable for their peculiar structure and great size : some specimens are estimated to have been three or four feet in length ; they are supposed to be the foliage of an arborescent fern. This species is only known in the Triassic formation of the Vosges. The specimen in the Museum shows the fructification, and was collected and presented to me by the late M. Voltz of Strasburg.



LIGN. 7.—ANOMOPTERIS MOUGEOTTI. THE TRIAS. NEAR SALTZBURGH.
Fig. 1. Portion of a frond in fructification.
2. A part of the same magnified.

FERN-STEMS—(*Caulopteris*).—*Case D.*—Flattened stems, marked with discoidal, oblong, or ovate scars, arranged longitudinally; these are in all probability the trunks of the arborescent ferns whose foliage abounds in the carboniferous deposits.

SIGILLARIA.—*Case C. Upper Shelves.*—Among the most common and striking objects that arrest the attention of a person who visits a coal-mine for the first time, and examines the fossil vegetable remains which lie profusely scattered among the heaps of shale, are long, flat, narrow slabs, with a black glossy surface, fluted longitudinally, and uniformly pitted with deep symmetrical imprints, disposed with great



LIGN. 8.—SIGILLARIA SAULLII. COAL DEPOSITS. A PORTION OF A FLATTENED STEM.

a. External surface marked by the scars of the petioles.
b. The inner surface exposed by the removal of the bark.

regularity between the grooves. There are many fine specimens on the upper shelf in Case *C*. These slabs are commonly from half-an-inch to an inch in thickness, and have similar markings on both sides. They are the flattened trunks of large trees covered by the bark in the state of coal, the markings on the surface being the scars left by the separation of the leaf-stalks, like the cicatrices on the stems of arborescent ferns. The name *Sigillaria* has been given to these trees from

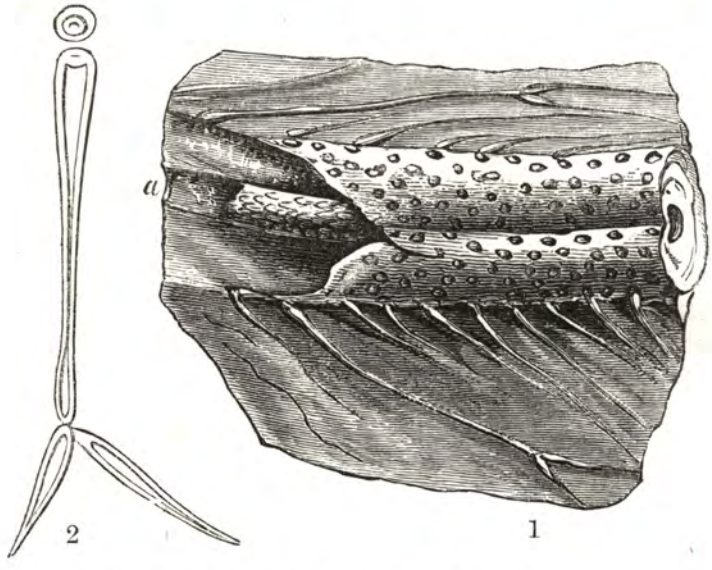
the uniformity of the imprints suggesting the idea of impressions made by a seal. The stems vary from a few inches to several feet in diameter, and attain a length of fifty or sixty feet. They are often found erect, and uncompressed; in general, all vestiges of internal structure are lost, the cylinder of carbonized bark being filled up with clay or sand, and giving rise to large cylindrical casts of stone, slightly impressed with the longitudinal furrows and leaf-pits. A few examples of silicified stems have been discovered, and by sections, and a microscopical examination of these fossils, the internal organization of these remarkable extinct types of vegetation has been ascertained. The Sigillariæ were tall erect trees, with a regular and cylindrical stem, having no side branches, but becoming dichotomous at the summit. Their superficial bark was hard and durable, channelled longitudinally, bearing leaf-scars that are of a rounded form above and below, and angular at the sides, often oblong in relation to the stem, and having three vascular pits, one central and small, and two lateral of a larger size. The internal structure bears most analogy to that of the Cycadeæ, and the foliage consisted of long linear carinated leaves. The Sigillariæ, therefore, differ essentially from the arborescent cryptogamia, which they somewhat approach in having scalariform vascular tissue, symmetrical and regular leaf-scars, and branchless trunks. More than fifty species have been determined.[1]

Sigillaria (or *Sagenaria*) *caudata.—Case C.*—On the front of the middle shelf of this case, immediately above the label—*Filicites*—there is a sandstone cast of an uncompressed Sigillaria, deeply imprinted with the cicatrices left by the petioles, which is remarkable for the extraordinary sharpness of the scars, and the geological position ascribed to it. It was discovered (as I was informed by the Dean of Westminster, when examining with him the fossil plants in this case) in the *Greensand*, which is the lowermost group of the chalk formation. Now, as the Sigillariæ are peculiar to the carboniferous epoch, no other instance being known of any vestiges of this tribe of vegetables in subsequent deposits, it is

[1] Figures of Sigillariæ in "Wonders of Geology," p. 719; "Medals of Creation," p. 129, Pl. V.; "Pictorial Atlas," Pl. XIX., XX., XXIV.

important that the habitat of this fossil should be ascertained, and its geological age determined.

STIGMARIA. — *Cases E, F.* — On the upper shelves of these cases are deposited numerous specimens of certain fossil vegetables which are abundant in most coal fields, and are commonly known as *Spotted-stems*, or Stigmariæ. These bodies, when uncompressed, are of a cylindrical form, from one to six or seven inches in diameter, and of great length—sometimes twenty or thirty feet—gradually lessening, and dividing and subdividing, as they extend. The surface is marked with distinct pits or areolæ, which are either oval



LIGN. 9.—STIGMARIA FICOIDES. COAL DEPOSITS.

Fig. 1. Portion of a root. ($\frac{1}{3}$ *nat. size.*) The internal axis is seen at *a*.
2. One of the rootlets, with a tubercle, to show the mode of articulation.

or circular, with a slight elevation or tubercle in the centre of each ; they are disposed around the stem in a quincunx order somewhat regularly. When these fossils are observed in situ, or are compressed and imbedded in shale or stone, as in some of the specimens in Case *F*, long, tapering, subcylindrical fibres, are seen to proceed from the pits or depressions with which the surface is studded, each being attached by its base to the tubercle or eminence in the centre of the areola. When

broken transversely, a small cylindrical core or axis is found extending longitudinally throughout the stem like a medullary column, (*a*, *Lign.* 9.) and there is generally a depression or furrow running parallel with it on the outer surface.[1]

The nature of these fossil vegetables was long a perplexing question, for no specimens had been found in connexion with any of the stems, branches, or foliage, that abound in the coal deposits. At length, the discovery of a dome-shaped mass, from which radiated numerous stigmariæ, seemed to afford a clue to the solution of this botanical problem, and it was concluded by the eminent Authors of the "Fossil Flora of Great Britain," that the original belonged to a tribe of plants which inhabited swamps, or still and shallow lakes, and were characterised by a low truncated stem, having long horizontal branches beset with cylindrical, and, probably, succulent leaves, that either trailed on the surface of the swamp, or floated in the water.[2]

But within the last few years, the occurrence in various carboniferous deposits, of erect stems of Sigillariæ, has shown that the Stigmariæ are nothing more than the roots of these and other congenerous trees; an opinion maintained by the Rev. H. Steinhaur more than thirty years ago, and subsequently affirmed by M. Adolphe Brongniart, who found, on examining microscopically the internal structure of a silicified specimen in which the vascular tissue was preserved, that the organization bore as close an analogy to that of the Sigillariæ, as exists between the roots and trunks of certain dicotyledonous trees.[3]

Upright stems of Sigillariæ, with Stigmaria-roots.—To the sagacity and persevering researches of Mr. Binney of Manchester, science is indebted for the establishment of this highly interesting fact. In 1844, Mr. Binney discovered at St. Helen's, near Liverpool, an erect trunk of a Sigillaria nine feet high, to which were attached ten roots that extended several feet into the under clay, in their natural position, and

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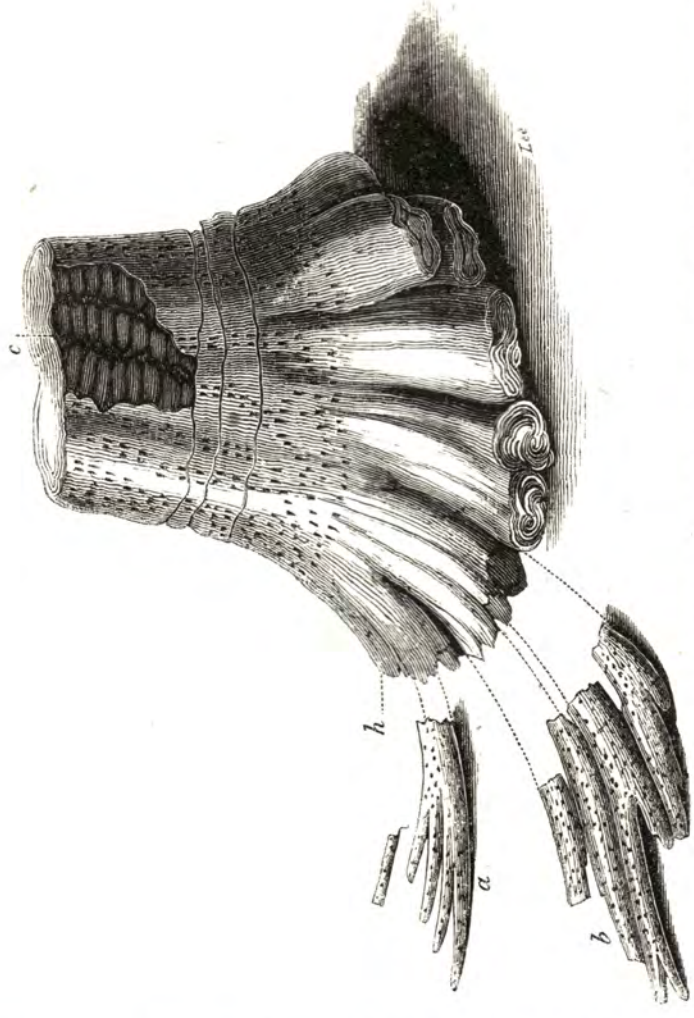
[1] Figured in "Medals of Creation," p. 140, Pl. III. fig. 1; "Pictorial Atlas," Pl. XXI.—XXIII.

[2] It is to be regretted that this erroneous conjecture is reprinted from Dr. Buckland's Essay, in the recent work of Messrs. Chambers on the British Museum, p. 251.

[3] See "Medals of Creation," p. 143.

these roots were unquestionable Stigmariæ; the tubercles with the attached rootlets (the supposed leaves), being clearly



LIGN. 10.—ERECT STEM OF SIGILLARIA WITH STIGMARIA-ROOTS; IN A COAL-MINE IN NOVA SCOTIA. ($\frac{1}{12}$ *nat. size.*)

This stem is a solid cast in claystone, the carbonized bark retaining the characteristic markings, only remaining in a few places.

c, the decorticated part of the stem, which is covered with minute scales as far as the point *h*, which is a few inches below the first ramification of the roots. The carbonaceous crust that enveloped the roots was thick at the upper part, but gradually became thinner towards the extremities, and at *a*, and *b*, was a mere pellicle that fell off on the slightest touch.[1]

[1] Journal of the Geological Society of London, 1847 and 1849.

displayed : and on the floor of the Victoria mine at Dunkinfold, near Manchester, at the depth of 100 feet, Mr. Binney

LIGN. 11.—STEM OF A SIGILLARIA BROKEN OFF CLOSE TO THE ROOTS. ($\frac{1}{12}$ *nat. size.*)
In a coal mine at Cape Breton, Nova Scotia.
a, the depression left by the removal of the stem.

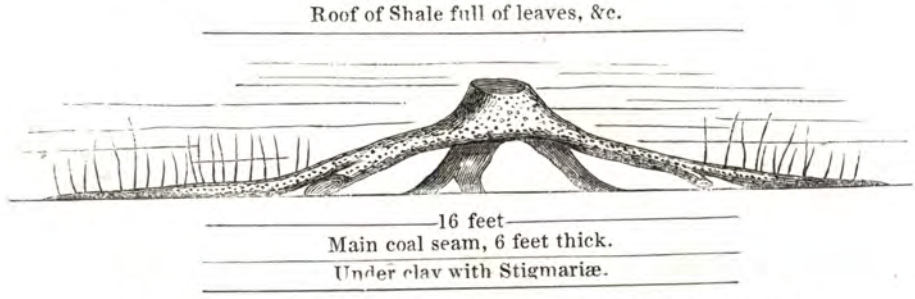
laid bare a magnificent trunk of a Sigillaria, with Stigmaria-roots extending upwards of twenty feet in the clay.

In the Pictou coal-field of Cape Breton, in Nova Scotia, many similar instances have been brought to light ; the remarkable phenomenon existing in that locality, of successive

carboniferous deposits containing scores of erect trees with their roots spreading into their native soil, presenting peculiar facilities for verifying the observations made in England. In an interesting memoir on the coal-fields of Nova Scotia, Mr. Richard Brown has given a detailed account of numerous examples of stems of Sigillariæ, and of Lepidodendra, (a tribe of gigantic club-mosses of which we shall treat in the sequel,) with the roots attached; these roots having, in every instance, the character and structure of Stigmariæ. The annexed figure (*Lign.* 10) represents an erect trunk of *Sigillaria alternans*, with roots (Stigmariæ) extending into the surrounding clay.

In another example (*Lign.* 11.) discovered by Mr. Brown, the stem of the tree was broken off close to the roots, and the hollow cylinder of bark (*a*,) was bent down and doubled over by the pressure of the surrounding mud, so as effectually to close up the aperture, and leave only a few irregular cicatrices converging near the apex; the structure, arrangement, and number of the tap-roots, as well as the horizontal ramifications, were similar to those in *Lign.* 10. This fossil explains the true nature of the "dome-shaped" plant figured in the Fossil Flora, and in Dr. Buckland's Essay.[1]

I subjoin another sketch from the same memoir in illustra-



LIGN. 12.—STEM OF A LEPIDODENDRON, WITH STIGMARIA-ROOTS.
(*From Mr. Brown's Memoir.*)

tion of this subject: the stem of a *Lepidodendron* with roots, which are Stigmariæ.

The stems and the roots of this tree were similar to the

[1] See "Pictorial Atlas of Organic Remains," pp. 198—202.

fossils in Cases *D*, *E*, and *F*, which are respectively labelled Lepidodendron, and Stigmaria.

Besides the fine specimens of Stigmariæ in the cases above referred to, there is an instructive example of these trailing

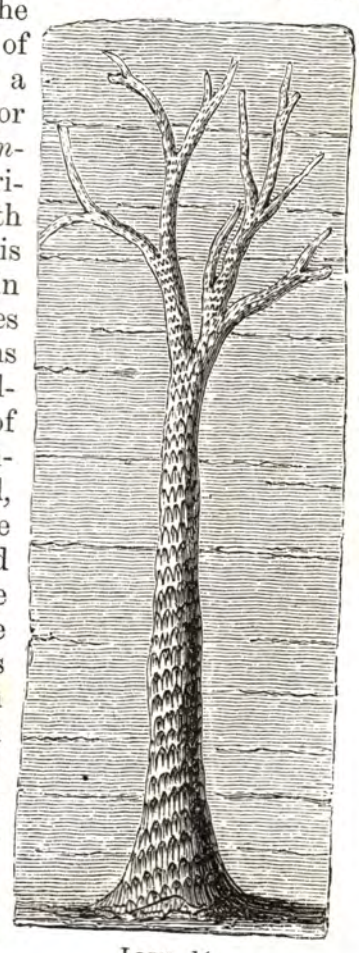
LIGN. 13.—PORTION OF A BRANCH OF LEPIDODENDRON: IN COAL SHALE, NEWCASTLE.
Fig. 2. A scar of a petiole. (*Nat. size.*)

roots, twenty-six feet long, attached to a board, placed over the doorway of Room I. at the entrance from the Zoological Gallery.

Calamitia.—Case E.—On the left hand of the lower compartment, there are placed on some shallow ledges, many specimens of the silicified stems named *Calamitia* by M. Cotta,

and *Calamodendron* by M. Brongniart. These are the remains of plants altogether different from any known living vegetables in their internal organization. The disposition of the ligneous cylinder and of the medullary rays, indicate a dicotyledonous structure; but the vascular tissue approaches that of the gymnosperms, and is still more analogous to that of the Sigillariæ.

LYCOPODIACEÆ — (*Lepidodendron, Lepidostrobus, Lepidophyllum*).—*Cases C, D, E.*—The upper compartments of these cases [marked 3, 4, and 5, in the room] contain a rich assemblage of the stems, leaves, and fruits, of a gigantic tribe of club-mosses (or Lycopodiaceæ), named *Lepidodendron* (or scaly-tree), from the triangular scars of the petioles with which the surface of the stem is covered. These plants rivalled in number and magnitude the Calamites and Sigillariæ, and their remains are profusely distributed in the coal-shales, occurring, like the stems of the former, both erect and cylindrical, and prostrate and compressed, as in the examples before us. Some of these trees have been discovered almost entire, from their roots to the topmost branches. Near Newcastle in the Jarrow coal-mine, a tree was laid bare that measured forty feet in height, and above thirteen feet in diameter at the base; it divided towards the summit into about twenty branches. The foliage (*Lepidophyllum*) of these trees consisted of simple linear leaves, spirally arranged around the stem; and these appear to have been shed from the base of the trunk by age. The scars produced by the attachment of the petioles were persistent, and are seldom obliterated in the



LIGN. 14.
LEPIDODENDRON STERNBERGII.
A tree 39 feet high, and 13½ feet wide at the base. Coal mine, Newcastle.

fossils; the branches and twigs are generally covered with foliage.[1]

Lepidostrobus.—Case D.—The seed-vessels are cylindrical cones composed of winged scales, their axis being traversed by a longitudinal cavity or receptacle, and terminating in rhomboidal disks, imbricated from above downwards. They occur of various sizes—from two to six inches long, and one or two inches in circumference. These fruits, like the fronds of ferns, often form the nuclei of the ironstone nodules so abundant in the carbonaceous clays, and are frequently mineralized by brilliant pyrites, and galena or sulphuret of lead. There is a beautiful suite of these fossils (the greater part from the Author's collection) in Case *D*: they were obtained from Coalbrook Dale. When imbedded in the rock, the cones are often fringed with linear-lanceolate bracteæ.

Notwithstanding the great disparity in size between the existing family of club-mosses or Lycopodiaceæ, most of which trail on the ground, and none exceed three or four feet in height, and the Lepidodendra, M. Brongniart, Dr. Joseph Hooker, and other eminent botanists, concur in regarding these gigantic trees of the coal flora as belonging to the same tribe, and only generically distinct.[2]

The visitor's attention should be directed to the beautiful specimens of *Lepidodendron selaginoides* on coal-shale, on the upper shelf of Case *D*; and of *L. punctatum*.

Ulodendron, Bothrodendron, Halonia, Megaphyton.—Case E.—The specimens to which these names are attached, are the stems of plants belonging to the same family as the Lepidodendra, but supposed to be generically, or sub-generically, distinct. The *Bothrodendron* (pitted-stem) is remarkable for two vertical rows of deep oval depressions, on opposite sides of the stem, which more resemble the attachment of the bases of cones, than of leaves. In *Megaphyton* the stem is not furrowed, the leaf-scars are very large and of a horse-shoe form, and disposed in two vertical rows on each side.[3]

[1] Figured in "Medals of Creation," pp. 146, 149; "Wonders of Geology," p. 718; "Pictorial Atlas," Pl. I. III. IX. XXVI. XXVII. XXXIII.

[2] The botanical reader interested in the subject is referred to "Memoirs of the Geological Survey of Great Britain," vol. ii.; and "Dict. Univ. d'Hist. Nat.," Article, "Tableau des Genres de Végétaux Fossiles," Paris, 1849.

[3] "Pictorial Atlas," Pl. XXV.

On the uppermost shelves are the *Haloniæ;* these fossils are sandstone casts with a thin carbonaceous crust, of cylindrical stems, which are beset with large elevated knobs or projections disposed in quincunx; these are not produced by the attachment of petioles, but are sub-cortical protuberances: the botanical affinities of these plants are not satisfactorily determined.[1]

Sternbergia; Artesia.—Case E.—The fossil stems thus labelled are on the shelves below the Haloniæ; they are supposed to be the carbonized medullary axis of a genus of plants distinct from the Lepidodendra, and named *Lepidophloios* by Count Sternberg.[2]

THE CARBONIFEROUS FLORA.—Although there are vestiges of many coniferous trees, and of some endogenous plants, in the coal-strata, yet as the vegetables we have cursorily examined constitute the essential features of the flora of the carboniferous epoch, a few general remarks on the subject will not be irrelevant in this place.

The peculiarity of this flora is the great number of the vascular cryptogamous plants, which amount to two-thirds of the species of vegetables discovered in the carboniferous deposits. With these are associated a few palms, coniferæ, cycadeæ, and some dicotyledons, allied to the cacteæ and euphorbiaceæ. The magnitude and numerical preponderance of plants analogous to the *Ductulosæ*, but differing in species and genera from existing forms, constitute, therefore, the most striking botanical feature of the flora of this epoch. Thus we have trees allied to the equisetaceæ, thirty or forty feet high, and eighteen inches or more in circumference (*Calamites*); arborescent club-mosses (*Lepidodendra*), attaining an altitude of sixty or seventy feet; and zamia-like coniferæ (*Sigillariæ*), fifty feet high. Of these ancient and extinct types, the latter tribe is especially remarkable in consequence of the peculiar circumstances under which the erect stems and roots occur, and which it will here be necessary to consider, as the phenomenon is highly interesting, and bears strongly on the question as to the mode in which the beds of coal, clays, and shales, that

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[1] Figured in "Medals of Creation," p. 150.

[2] See M. Brongniart's "Tableau de Vég. Foss." p. 43; "Pictorial Atlas," Pl. XVIII.

constitute the deposits termed coal-measures, were accumulated. Every coal-field (as a group of these strata is generally termed) is composed of a succession of a triple series of beds; viz. — firstly, the lowermost: a tough argillaceous earthy stratum, termed under-clay, on which the bed of coal invariably rests; and it is in this deposit that the roots (Stigmariæ) of the trees are always found, and commonly parallel with the plane of the strata; these are generally the only vegetable remains contained in this bed, though the clay is occasionally black from an intermixture of carbonaceous matter. Secondly, the coal, which is composed of the stems and foliage of trees transmuted into a bituminous carbonized mass: large stems, branches, or leaves, are but seldom found in it. Thirdly, the roof, or overlying stratum, consisting of slaty clay, and water-worn detritus of other rocks transported from a distance, and full of detached leaves, and flattened and broken trunks and branches: it contains layers and nodules of ironstone enclosing leaves, insects, and crustaceans. In some localities beds of fresh-water shells—as mussels,—in others marine shells, are intercalated: finely laminated clays, micaceous sand, grit, pebbles of limestone and sandstone, are sometimes imbedded in it. Thus it seems probable that the under-clay is the natural soil in which the coal-trees grew, the roots often remaining in their original position and spreading out from the trunk: the coal is formed of the carbonized stems and foliage; and the roof, or upper bed of shale and clay, is composed of the leaves and branches of a forest that was overwhelmed and engulfed beneath an accumulation of transported detritus.[1]

Psarolites or Psaronius.—*Cases C, D, E. Lower Shelves.* [3 *to* 5.] — On these shelves is an extensive series of silicified stems, many of them cut transversely and polished; the specimens labelled as above are chiefly from the Triassic or New Red Sandstone deposits of Chemnitz, near Hillersdorf, in Saxony. They are portions of petrified trunks of trees allied to the arborescent ferns and club-mosses, and possess a remarkable internal structure, that is exquisitely preserved in many of the petrifactions before us. The transverse sections

[1] For a full consideration of this subject see "Wonders of Geology," pp. 669, 718, 731: "Pictorial Atlas of Organic Remains," p. 181.

exhibit the arched bundles of vascular fibres which compose the ligneous cylinder, surrounded by the cellular tissue. From the stellated markings produced by sections of the vessels that compose the tissues, and are visible to the unassisted eye, these fossils have obtained the popular name of *Staar-stein* or Star-stones.

Recent investigations have shown that these stems consist of two distinct parts; namely, an inner axis, surrounded by a zone composed of numerous cylindrical bundles of vessels, which are supposed to be roots that proceeded from the stem near its base. In the exterior portion the air-roots have a vascular tissue, but there is in many examples a delicate interstitial cellular tissue. In the axis, the vessels form zigzag or vermiform bands resembling those in ferns, and which are entirely composed of barred or scalariform vessels. The Psarolites are therefore considered by M. Adolphe Brongniart to be the bases of the trunks of lycopodiaceous trees; while M. Cotta and others regard them as true arborescent ferns. The external surface of the specimens I have examined has a ligneous structure, and is of a dark reddish brown; internally they are of a dull red colour mottled with various tints of blue and yellow, from the infiltrated chalcedony with which the vessels of the tissues are more or less permeated.[1]

ASPHODELEÆ—(*Clathraria, Endogenites, Dracæna*).—*Case E*.—On the lower shelves of this case there are specimens of three remarkable fossil plants; two of which were first discovered by the Author in the Wealden deposits of Tilgate Forest; the other by Mr. Bensted in the *Kentish-rag* near Maidstone. They are placed under the name *Asphodeleæ*.

CLATHRARIA (*C. Lyellii*).—*Case E* [5].—The *Clathraria* (latticed-stem), so named from the appearance of the cicatrices left by the petioles, is a remarkable tribe of terrestrial plants allied to the Cycadeæ, that flourished during the period when the Wealden beds of the south-east of England, and the lowermost and middle cretaceous strata were deposited; for remains of these plants occur in the greensand and chalk marl.

All the specimens in the Case were collected by the Author

[1] Beautiful coloured figures are given in "Pictorial Atlas of Organic Remains," Pl. VIII. M. Cotta has published an able work on the subject, in which nearly thirty species are described. See also M. Brongniart's "Tableau des Genres de Vég. Foss." p. 44.

from the calciferous grit of Tilgate Forest; and they form a highly instructive series, comprising portions of stems scored with the imprints of the petioles, the internal imbricated axis, leaf-stalks, and indications of the foliage and flower-buds.

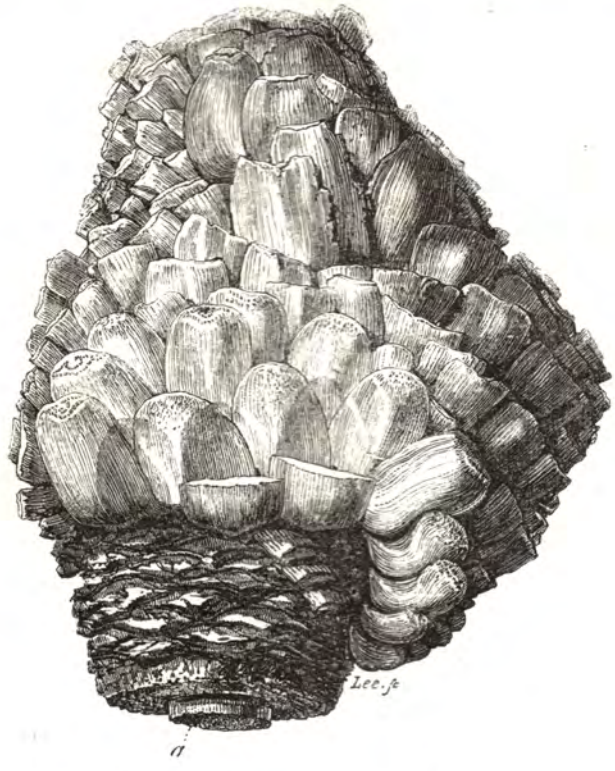
LIGN. 15.—WATERWORN SPECIMEN, SHOWING THE EXTERNAL SURFACE OF THE STEM OF CLATHRARIA LYELLII. WEALDEN.

($\frac{1}{3}$ *nat. size.*)

The stem of the Clathraria is composed of an axis or internal column, the surface of which is covered with reticulated fibres. The large branched fossil lying on a slab of stone in the middle of the case, is the finest specimen of this part hitherto obtained: it was discovered, with bones of the Iguanodon, in a quarry near Cuckfield, Sussex, in 1820. The axis is invested with a very thick bark formed of the consolidated bases of the leaf-stalks, the insertions of which are rhomboidal and transverse. The outer surface of the bark is in consequence marked with elevated lozenge-shaped cicatrices, separated from each other by a marginal furrow, which is surrounded by a parallel ridge or band of a fibrous structure. The cortical portion of the stem is in general converted into a cylinder of stone, which in some instances will separate from the axis. There is a beautiful specimen of this kind in the case; and likewise one in which the axis projects, and is surrounded by the bark.[1] The axis is solid, and has its surface strongly marked with interrupted reticulated ridges. This surface has generally patches of vascular tissue adhering to it; and on some parts there are deep pits or lacunæ, which probably contained a resinous secretion. I have spared neither trouble nor expense in endeavouring to detect the organization of this plant; scores of sections of stems have been made and examined microscopically, but very few specimens exhibit any

[1] This, and the large branched specimen of the axis, were first described and figured in my "Fossils of Tilgate Forest," Pl. I.

traces of structure; and in those which retain some vestiges of organization, the siliceous mass into which the vascular tissue is transmuted, is not sufficiently transparent to yield satisfactory results; it can only be inferred that in their internal organization, as in their external characters, the Clathrariæ were most nearly allied to the Cycadeæ or Zamiæ. A remark-



LIGN. 16.—CLATHRARIA LYELLII. CHALK MARL.[1]

($\frac{1}{6}$ *nat. size.*)

The summit of a stem garnished with petioles; the lower part shows the cicatrices left by the removal of some of the petioles: *a*, the internal axis.

able specimen discovered in a stratum of chalk marl near Bonchurch, in the Isle of Wight, throws much light on these interesting plants: and I insert a figure, to illustrate the fossils in the case before us. It consists of the summit

[1] This specimen is in the collection of Captain Ibbetson, F.R.S.

of a stem garnished with persistent petioles or leaf-stalks; it is fifteen inches in length, is perfect at the top, and at the fractured end the internal axis, surrounded by the false bark formed by the confluence and consolidation of the bases of the petioles, is exposed. (See *Lign.* 16, *a*). The stem at the lower part is bare, and exhibits the characteristic lattice-like scars. The petioles are for the most part entire; some of them are abortive, and others which have supported leaves are marked on the summits with vascular pits, indicating that the foliage was shed naturally.[1]

There is a fragment of an internal axis, about six inches in length, that is placed near the large slab, which will interest the botanical observer, and requires a passing notice. This specimen is naturally separated transversely into two portions; the lower one is convex on the upper part, and is traversed by fibres, which extend from the outer surface across to the opposite side; the corresponding face of the other portion is concave, and closely adapted to the convexity, leaving on one side an oval hollow, which denotes the origin of a floral axis or panicle, as is proved by the direction of the fibrous structure.[2]

From the obscure traces of leaves that have been observed in some examples, it seems probable that the foliage resembled that of the Yucca. Small kernels or seed-vessels somewhat resembling those of certain palms, as for example the Areca, are often associated with the stems of Clathrariæ, and may have belonged to those plants. The remains of these vegetables are generally deposited among gravel, or sand, with water-worn bones of reptiles; and are occasionally imbedded in the fluviatile conglomerate of the Wealden.

Endogenites Erosa.—Case E.—The stems thus labelled are also from the Wealden deposits; they often occur in the layers of lignite which traverse the clay-beds in some parts of Sussex. These stems are from one to eight inches in diameter, and five or six feet in length, and of a very irregular shape; there are no indications of branches. Some are subcylindrical in the middle, and gradually taper to a point

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[1] See "Medals of Creation," p. 182; "Wonders of Geology," p. 395; "Geology of the Isle of Wight," p. 292.

[2] Figured in "Medals of Creation," p. 183.

at each end; others are of a depressed clavated form, like some of the Cacteæ or Euphorbiæ. These fossils are generally transmuted into a hard and fine siliceous grit, and, when in situ, are invested with a friable carbonaceous bark of a glossy lustre, which soon falls to pieces on exposure to the atmosphere; so that cabinet specimens seldom retain any vestiges of this integument. When this crust of coaly matter is removed, the surface of the silicified stem is seen to be traversed by numerous fine meandering grooves, and deep, tortuous, tubular channels, disposed in an irregular manner in a longitudinal direction. These channels or vessels, which are generally lined with quartz crystals, give the surface that eroded appearance whence the specific name *erosa* was derived: they are not, however, the effect of erosion, but of the original structure of the plant; they traverse the substance of the stems, and although no symmetrical arrangement is apparent, this anomaly is probably attributable to the changes which the vegetable organization has undergone during its mineralization. In one instance (a specimen from the Wealden of the Isle of Wight), bundles of vascular tissue, arranged in a flexuous zone round the margin of the cylinder, are observable in polished sections under the microscope; the structure approaches more nearly that of the Cycadeæ than of the Euphorbiaceæ, with which some botanists have associated these enigmatical plants of the Wealden flora.[1]

Dracæna (*D. Benstedi*).—*Case E.*—In the lowest department of the same case are fragments of a large fossil stem allied to the *Dracæna*, or Dragon-blood Tree, discovered by Mr. W. H. Bensted, of Maidstone, in a quarry of Kentish Rag, near that town; a locality to which we shall more particularly allude in the sequel. The largest portion is two and a half feet in length, and eight inches in diameter; the surface is marked with interrupted annular ridges, indicating amplexicaul leaves. These fossils were found associated with drifted coniferous wood, and bones of turtles and iguanodons.

Medullosæ.—*Case D.*—In the lower division, beneath the Lepidostrobi, there are many specimens, some cut and po-

[1] Figured in "Fossils of Tilgate Forest," Pl. III.; "Geology of the S.E. of England," Pl. I.: by Dr. Fitton, in "Geol. Transactions," vol. iv.

lished, of small silicified stems, from Chemnitz in Saxony (I believe, from the carboniferous deposits), the internal structure of which is peculiar. The vascular tissue resembles that of Dracæna, but with essential differences, which render it difficult to establish any relation with existing types. M. Brongniart is of opinion that they will be found to belong to the Cycadeaceæ.

Fossil Palms.—*Cases D, E.* [5. c.d.]—The trees of this family, the greater number of which inhabit intertropical regions, are remarkable for their elegant form and peculiar aspect. They have a single cylindrical stem, which rises to a great height, and is crowned with a canopy of foliage, the leaves being very large, and either pinnated or flabelliform, and plaited in regular folds. The Date and Cocoa-nut are well-known examples of the fruit. The surface of the stem is scored with transverse scars left by the petioles.

In a fossil state, the remains of this family are very abundant; the stems with their external characters and internal organization preserved, and the leaves and the fruit, of several extinct species, have been discovered; chiefly in tertiary deposits.[1] From the manner in which the specimens are arranged in the collection, it will be convenient to notice in the first place the fossil Palm-nuts in the case before us.

Fruits of Palms, from the Isle of Sheppey.—*Case E.*—On the right hand of the central compartment in this case, there is a very small collection of fossil fruits, from the well-known productive locality of this class of organic remains, the Isle of Sheppey; and it is much to be regretted that our National Museum is so deficient in these most interesting relics of this ancient tertiary flora; especially when from the unrivalled and inexhaustible mine of these botanical treasures in the little Island at the mouth of the Thames, there might be obtained in the course of a few months, and at a trifling cost, a more extensive and important series of the fruits of the Eocene periods, than is contained in all the museums of Europe.

Referring the reader to "Medals of Creation," pp. 176, 897, for a particular account of these fruits, and the cir-

[1] See "Medals of Creation," p. 173.

cumstances under which they occur, I proceed to notice the only specimens worthy of remark. These are two or three examples of the nuts of an extinct genus of palm, closely allied to the recent *Nipa*, which is a low shrub-like plant that inhabits the Moluccas, growing in marshy tracts near the mouths of rivers, where the water is brackish. The Nipa has borne fruit in the conservatory of Mr. Yates, of Lauderdale House, Highgate. The fossil fruits (named *Nipatites Parkinsoni*), are known to the resident dealers and collectors at Sheppey as "*petrified figs.*" The nut or seed, and its pericarp or husk, are often well preserved, as in one of the specimens in the case before us.[1] Mr. Bowerbank, who some years since assiduously collected the fossil fruits of the Isle of Sheppey, and published three numbers of a work on the subject, whose excellence renders its discontinuance much to be regretted, has figured and described several species.[2] Mr. B. observes, that "if the habits of the plants to which the fossil fruits belonged were similar to those of their recent analogue, the *Nipa*, it will account for their abundance in the London clay in the Isle of Sheppey; which formation, from the great variety of the fossilized stems and branches, mixed up with star-fishes, shells of mollusks, and bones of fishes, crustaceans, and reptiles of numerous marine and fresh-water genera, is strikingly characterized as having been the delta of an immense river, which probably flowed from near the equator towards the spot where these interesting relics are deposited."[3]

Palmacites Lamanonis.—Case E. [5.]—In the narrow recess in this case, on the left of the door-way, there is a palm-leaf imbedded in cream-coloured limestone, from the Eocene deposits of Aix, in Provence (this specimen was formerly in the Author's collection). The leaves of several extinct species of

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[1] Figured in "Pictorial Atlas," Pl. VI. VII.

[2] "History of the Fossil Fruits and Seeds of the London Clay of the Isle of Sheppey." 1840: London.

[3] As the seed-vessels and other vegetable remains in the Isle of Sheppey are all of a tropical character, while those found in the Eocene strata of Alum Bay, Bournemouth, and Newhaven, are of a temperate climate, as Nerium, Platanus, &c., Prof. E. Forbes infers that the former should be regarded as transported from distant lands by currents, and the latter as the true flora of the country inhabited by the Palæotheria and other associated mammalia.

palms have been collected from the tertiary strata of various parts of the Continent, but the first example discovered in England was obtained a few months since, from the fresh-water tertiary deposits at White-Cliff Bay, in the Isle of Wight, by Mr. Fowlstone, of Ryde.[1]

LIGN. 17.—PALM-LEAF FROM EOCENE STRATA. ISLE OF WIGHT.
Palmacites Lamanonis. (¼ *nat. size.*)

Palm-stems.—Cases D. and E.—The lower shelves of Case *E*, beneath the fossil fruits from Sheppey, contain many specimens of silicified stems of palms; and on the top of Case *D*, there are several very large petrified trunks from Antigua, and from the Eocene deposits of India. Some of these fossils retain vestiges of the air roots which proceed from the lower part

[1] See "Geological Excursions round the Isle of Wight," &c., 2d edit. 1851, p. 431.

of the stem in this tribe of vegetables. The internal structure is in most instances exquisitely preserved, and sections under the microscope exhibit the organization of the original as distinctly as in the recent state. Some of these fossils are very beautiful objects under a slightly magnifying power, whether viewed by reflected or transmitted light, owing to the rich tints of crimson, yellow, brown, &c. of the silex into which the vascular tissue is transmuted.[1]

CONIFERÆ.—*Case F.* [6. A.D.E.]—The trees and plants that are comprised under the term Coniferæ, or cone-bearing, from the form of their fruit, constitute an extensive and most important tribe, which is divided into two families: the *Coniferæ*, strictly so called, as the Pine, Fir, Larch, Cypress, &c.; and the *Cycadeæ*, of which the Cycas and Zamia of our conservatories are familiar examples. These families are distinguished from all other dicotyledons by the remarkable peculiarity of the seeds being originally naked or exposed, and not enclosed within an ovary; hence the botanical name of the order—*Gymnospermous Phanerogamiæ*.

The conifers are all arborescent, dividing into numerous branches, which are disposed with considerable regularity; many are among the loftiest trees on our globe. The leaves are in most species acicular, or needle-shaped, narrow and linear; in two or three, however, they are broad and flat. The structure of the wood, though dicotyledonous, is so peculiar, that it may be readily detected in a fossil state. There are no true vessels, and the ligneous fibres are disposed in series which extend parallel with the medullary rays, having on the corresponding surfaces, or laterally, rows of regular punctuations or ducts, with a central pore surrounded by a discoidal areola. These ducts or glands, when in double rows, are placed side by side in the European pines and firs; but in the Araucaria (Norfolk Island pine) they are arranged alternately; and such is generally the case in the fossil coniferous wood of the secondary and palæozoic formations of England.[2] Vestiges of the coniferæ occur in the various deposits from the earliest

[1] A specimen, as seen by reflected light, is figured in "Medals of Creation," Pl. V., fig. 1.

[2] See "Medals of Creation," Pl. V. p. 162; and "Wonders of Geology," 6th edit. pp. 696, 724.

traces of terrestrial vegetation to the present time.[1] The trunks and branches, leaves, and the fruits or cones, of numerous trees of this family abound in a fossil state, and in the Case before us, there are many interesting specimens which our limits will not permit us to dwell upon. There are fruits of pines and firs from the Crag deposits, and from the greensand of Kent; and foliage and stems of pines, araucariæ, thuytes, &c., from the Lias and Oolite.

Voltzia.—The Case *F* also contains some fine specimens of *Voltzia*, a genus peculiar to the Triassic deposits, and one of the most characteristic of the extinct fossil coniferæ. The leaves of these plants are alternate, and have much analogy in their form and arrangement with the foliage of the Araucariæ. The fruits are oblong cones, with scales slightly imbricated, which do not appear to have been contiguous, are cuneiform, and generally have from three to five obtuse lobes: the disposition of the seeds or grains is not determined.[2]

Fossil Cycadeous Plants.—The Zamiæ and Cycadeæ are plants with cylindrical stems, beset with thick scales, which are the bases of petioles that have been shed: the summit of the stem is crowned with elegant pinnated leaves with simple veins, and which in the young state are coiled up like a crosier, as in the ferns. The Zamiæ are generally short and robust plants, but the Cycadeæ are longer, and some species are bifurcated, and attain a height of from twenty to thirty feet. The fruits bear a general resemblance to the cones of the pines, but the seeds are naked. The Cycadeæ are natives of hot and humid climates, and inhabit the West Indies, Cape of Good Hope, the Molucca Islands, Australia, &c.

Numerous extinct species and genera of this family occur in a fossil state, and they are especially abundant in the secondary deposits—the Lias and Oolite. In England the most fruitful locality is the Yorkshire coast, near Scarborough, where, in the intercalated fluvio-marine clays and shales of the Oolite, leaves and fruits of numerous species are found in great variety and perfection. The foliage is changed into

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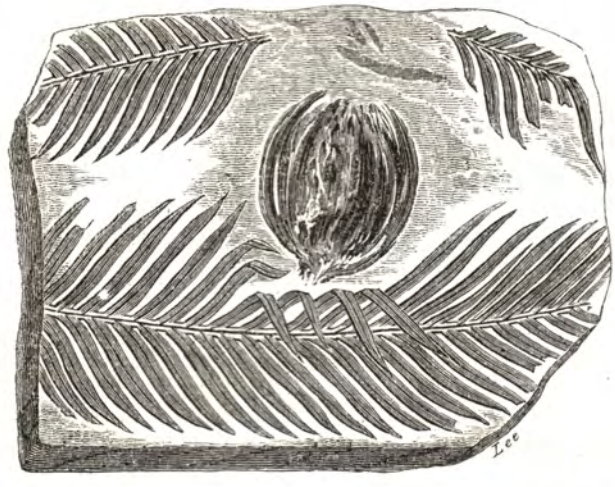
[1] The association of coniferæ with palms and arborescent ferns in the coal-measures, continues through all the subsequent formations to the tertiary.

[2] Two species of Voltzia are figured in "Wonders of Geology," p. 547.

carbon, but the venation is distinctly preserved. In the Stonesfield Slate, and in the Portland and Wealden strata, remains of this tribe are met with. The Museum contains many beautiful specimens of the leaves and fruits or cones of the ordinary species, which are arranged in the lower part of the Case before us—Case *F* of the plan, p. 10.

Of these the most striking is a well-known fossil plant of the Scarborough Oolite, whose leaves and fruits occur in profusion in some of the strata. This species has been described under the names of *Zamia gigas*, and *Z. Mantelli*, and has lately formed the subject of an interesting paper read before the Yorkshire Philosophical Society, by Professor Williamson of Manchester. Several specimens of the fossils locally termed "*collars*," are in the case before us: these bodies Professor W. has shown to be a zone formed by a scaly bud which originally enclosed the germ of these plants: in the progress of development the fruit burst through the upper part of the investing sheath, and, as it grew to maturity, rose above the incurved elongated scales, till the latter literally formed a zone or "collar" around the pedicle of the cone.



LIGN. 18.—LEAVES AND FRUIT OF ZAMIA LANCEOLATA, FROM SCARBOROUGH. ($\frac{1}{8}$ *nat. size.*)

Zamia lanceolata.—Case F.—On a slab of sandstone there is a beautiful example of the foliage of this plant, with a detached cone imbedded immediately above one of the leaves.

TREES AND CYCADEOUS PLANTS OF PORTLAND.—*Case F.*—In this Case, and on the top of the same, are many subcompressed, spheroidal, and sub-cylindrical silicified bodies, having the surface covered with lozenge-shaped scales; these are fossil plants closely allied to the recent Zamiæ, and were obtained from a remarkable stratum in the Isle of Portland, named the *dirt-bed*, which occurs in the quarries on the north of the island, a few feet above the layer of building-stone for which Portland has so long been celebrated. These fossils are found associated with the erect stems and prostrate trunks and branches of large coniferous trees, of which there is an example twelve feet long on the top of Case *D*. The circumstances under which these petrified trees and plants occur are so extraordinary, as to warrant a brief notice of the phenomenon in this place.

The Isle of Portland is a bold headland to the south of Weymouth, about four and a half miles in length and two in breadth, and is united to the mainland by a bar of shingle, called the Chesil Bank. It presents on its northern aspect a precipitous escarpment about three hundred feet high; and, declining towards the south, appears when viewed from the east or west, as an inclined plane rising abruptly from the sea. The base of the island consists of Kimmeridge clay, which is surmounted by beds of sand and thick layers of the oolitic limestone or Portland-stone. The strata dip to the south at an angle corresponding with the outline of the surface. The coasts are steep; the base of Kimmeridge clay forming a talus surmounted by perpendicular crags of oolite. The southern extremity consists of low limestone cliffs, which are worn into numerous caverns by the constant action of the waves.

The summit of the northern brow, to a depth of about thirty feet, is composed of beds of laminated calcareous shale, locally termed "*the Cap*;" and sections of these strata are exposed in the quarries that are opened for the extraction of the building-stone which lies beneath.

Immediately upon the uppermost bed of limestone, which is a coarse rock, full of cavities and imprints left by the decay of the usual species of marine univalve and bivalve shells of the Oolite, are layers of calcareous shale a few feet in thickness, in which no vestiges of marine fossils have been observed;

and whose laminated structure, and the presence of horizontal seams of carbonaceous earthy matter, with interspersions of vegetable remains, indicate a fluviatile or fresh-water origin. Upon these deposits is a layer, from one to two feet thick, of a dark brown friable loam abounding in lignite, and so similar in appearance to common vegetable earth or mould, as to have acquired the name of *dirt-bed* from the quarrymen. In and upon this bed are numerous petrified stems and branches of coniferous trees, and plants allied to the Zamiæ. Many of the trees and plants are standing erect, as if petrified while growing on the spot; the trunks of the trees extending upwards into the limestone above, and vestiges of the roots being traceable into the dirt-bed. The upright stems are in general a few feet apart, and but three or four feet high, and are broken and splintered at the top as if they had been wrenched off at a few feet from the ground. They are from a few inches to three or four feet in diameter; portions of prostrate trunks have been collected, indicating a total height of the originals of thirty or forty feet. In many instances fragments of branches remain attached to the stem. The cycadeous plants occur in the intervals between the upright trees, and the dirt-bed is so little consolidated that specimens, evidently standing in the position in which they originally grew, may be dug up with a spade. The strata above the dirt-bed consists of finely laminated cream-coloured shaly limestone, in which casts of the fresh-water crustaceans (*Cyprides*) so abundant in the Wealden, are the only organic remains hitherto noticed. These deposits are covered by the modern vegetable soil, which but little exceeds in depth the ancient one above described, and instead of supporting cycadeæ and pine-forests, barely maintains a scanty vegetation. Here, then, we have the remains of a petrified forest of the ancient world, the trees and plants, like the inhabitants of the city in Arabian fable, being changed into stone, yet still retaining the places they occupied when alive.[1]

MANTELLIA—(*M. nidiformis* and *M. cylindrica*).—*Case F.* —Such are the remarkable conditions under which the fossil cycadeous plants named *Mantellia* by M. Ad. Brongniart

[1] For geological details see "Wonders of Geology," 6th edit. p. 385; or, "Geology of the Isle of Wight," 2d edit. p. 393.

usually occur, and which invest them with a peculiar interest. These vegetables are from one to two feet in height, the circumference of the largest not exceeding three feet. The stem is sub-cylindrical, without a distinct central axis, and the surface is scored with rhomboidal scars, which are widest in the horizontal direction. There are two species, distinguishable by the form of the stems and the size of the cicatrices of the petioles. In one the stem is short and spheroidal, and the leaf-scars are relatively broader. (*M. nidiformis*) : this species is named "crow's nest" by the workmen, who believe these plants to be nests built by crows in the trees with which they are collocated, and that the trees and nests have become petrified together. The other species (*M. cylindrica*) is sub-cylindrical, and relatively higher than the former, and the cicatrices of the petioles are much smaller, indicating a more delicate foliage. The fruit of these plants is unknown ; one cone has been found which it is supposed belonged to the Mantellia, or some allied species ; it is figured in the Fossil Flora of Great Britain as *Zamia crassa*.[1]

LIGN. 19.
MANTELLIA NIDIFORMIS.
Isle of Portland,
($\frac{1}{12}$ *nat. size.*)

FOSSIL-WOOD AND TREES OF AUSTRALIA.—Table-case *a*.—In the recesses of the east windows, and in the table-cases beneath, there are many choice specimens of the wood, and two portions of very large trunks of coniferæ, from Van Diemen's Land and New Holland. This fossil wood is partly calcified, and partly silicified ; some portions being very earthy and friable, and effervescing strongly with acid, while other parts of the same stem are converted into chalcedony and semi-opal ; in both states the organic structure may be detected by the aid of the microscope.

The trees from which the specimens brought to England

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1 "Medals of Creation," p. 160, *lign.* 38.

The fossil plants of the Isle of Portland are admirably described and illustrated by Dr. Buckland, in Bridgewater Essay, p. 497, and pl. 60, 61. The species described in the text under the names assigned to them by M. Brongniart, are the *Cycadites megalophyllus* and *C. microphyllus* of Dr. Buckland.

were obtained, appear to occur under similar conditions, and to have been subjected to the same changes, as those of the Isle of Portland above described. They are found with the trunks erect, to the height of a few feet, in a bed of arid sand, apparently on the spots where they grew; the branches and upper part of the stems being scattered around. They so entirely preserve their natural ligneous appearance, that an agricultural colonist mentioned as among the extraordinary sights he witnessed on his first arrival in New Holland, the burning of trees into excellent lime to manure the ground.

A forest of these silicified trees occurs on the eastern coast of Australia under the following circumstances. At the base of a mountain range composed of conglomerates and sandstones, with subordinate beds of lignite, terminating on one side of Lake Macquarrie, an alluvial flat extends to the water's edge, covering the sandstone rock, which lies in situ beneath. Over this plain stumps of petrified trees project a few feet above the soil, presenting the appearance of a forest in which the trees are all cut or broken off at the same level. At the distance of a few yards from the shore, a reef is formed by vertical rows of stems, which project above the water. Many of the fossil trees on the shore have the remains of roots extending into the sandstone below the alluvial deposit; and, like those in the Isle of Portland, are in some instances surrounded by an accumulation of stone that forms a mound of a higher level than the surface of the ground. These trees are of a large size; often six feet in diameter. The concentric annular rings, and the medullary rays and the coniferous ducts, are beautifully preserved in silex and chalcedony; in several examples, from 60 to 120 annual circles of growth were observable.

In the valley of the Derwent in Van Diemen's Land, opalized coniferous trees of a similar character were observed under conditions yet more extraordinary, by the distinguished philosophical traveller, Count Strzelecki. Truncated stems of trees are standing erect in a bed of porous and scoriaceous basalt, and trachytic conglomerate: but in some instances these are only casts of trunks that were consumed by the melted basalt when first ejected. This curious phenomenon can only be explained by supposing that the silicified stems were able to resist the intensity of heat of the incan-

descent lava, while trees placed in circumstances unfavourable to their petrifaction were consumed: but the latter, being either saturated with water, or fresh and green, were consumed slowly, and left cylindrical moulds in the cooled basaltic scoriæ, with impressions of the external surface of the bark; and these moulds being filled up by a subsequent eruption, formed casts of the consumed trees in basalt.[1]

With this notice of the petrified forests of Portland and of Australia, our survey of the collection of fossil vegetables contained in the British Museum is brought to a close; for the objects that remain to be noticed in this room belong to a very different subject. Desultory and somewhat unconnected as the descriptions and illustrations have necessarily been, I would fain hope that this imperfect attempt to invest with a higher interest these relics of the extinct tribes of vegetables that flourished in the earlier ages of the earth's physical history, will not prove unsuccessful.

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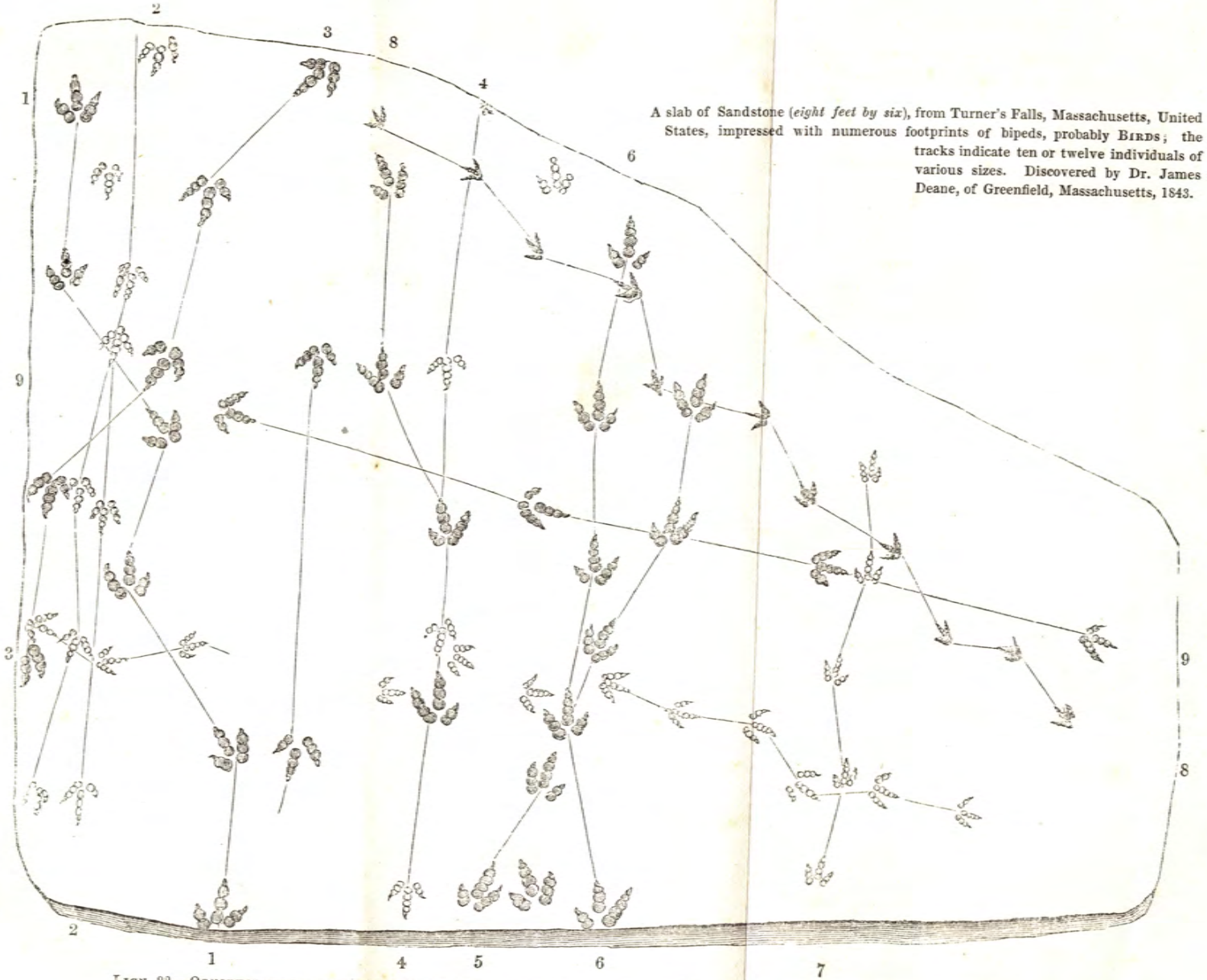
[1] "Physical Description of New South Wales," by Count Strzelecki.



A slab of Sandstone (*eight feet by six*), from Turner's Falls, Massachusetts, United States, impressed with numerous footprints of bipeds, probably BIRDS; the tracks indicate ten or twelve individuals of various sizes. Discovered by Dr. James Deane, of Greenfield, Massachusetts, 1843.

LIGN. 22.—ORNITHIC-NITES, OR FOOT-PRINTS OF BIRDS, ON SANDSTONE; IN ROOM I. GALLERY OF ORGANIC REMAINS, BRITISH MUSEUM.

To face p. 69.

CHAPTER I.

PART III.

FOOTPRINTS AND RIPPLEMARKS ON STONE—FOOTMARKS OF QUADRUPEDS ON TRIASSIC SANDSTONE—CHIROTHERIUM—ICHNOLITES FROM NEAR LIVERPOOL—ICHNOLITES FROM SAXONY—ORNITHICHNITES, OR FOOTMARKS OF BIRDS, FROM NORTH AMERICA—SPECIMENS IN THE BRITISH MUSEUM—IMPRESSION OF THE SKIN OF THE FOOT—SIR C. LYELL ON THE ORIGIN AND NATURE OF THE IMPRINTS.

FOOTPRINTS AND RIPPLEMARKS ON STONE.—The intelligent observer who has strolled along the strand of the sea-shore at low water, must have often seen the surface of the exposed sands deeply rippled by the waves of the ebbing tide, and have noticed the trails of mollusks, and the meandering furrows and ridges produced by worms or annelides, and the tracks of crabs, and sometimes the footprints of birds, and of dogs or other quadrupeds, that have walked over the soil whilst it was plastic, yet sufficiently firm to retain the markings impressed on it. Under certain conditions, these apparently evanescent characters are indelibly fixed on the stratum, and in rocks of immense antiquity successive layers of sandstone and shale, through a thickness of many hundred feet, are found deeply furrowed with the ripples of the waves that flowed over them, and pitted by the rain that has fallen upon them, and impressed with the footmarks of bipeds and quadrupeds that traversed the sands whilst the surface was in a moist and yielding state. Referring the reader to Sir C. Lyell's "Elements of Geology,"[1] or my "Wonders of Geology,"[2] for a full consideration of the physical conditions under which these phenomena must have been produced, I proceed to describe the slabs of sandstone traversed by footprints of bipeds and quadrupeds, that are affixed to the north wall, immediately opposite to the entrance of Room I.

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[1] "Elements of Geology," p. 297. [2] Vol. i. p. 372.

FOOTPRINTS OF QUADRUPEDS ON TRIASSIC SANDSTONE.[1]—Window recess between *c* and *d*, and upright case *e*.—The *Ichnolites* (as petrified footprints are scientifically termed) to which I would first call the visitor's attention, are those on the larger slab of sandstone, from near Storton, that is placed in the window recess, between *c* and *d*, and the two from Hildburghausen, in Saxony, that are deposited in an upright wall case at *e*.

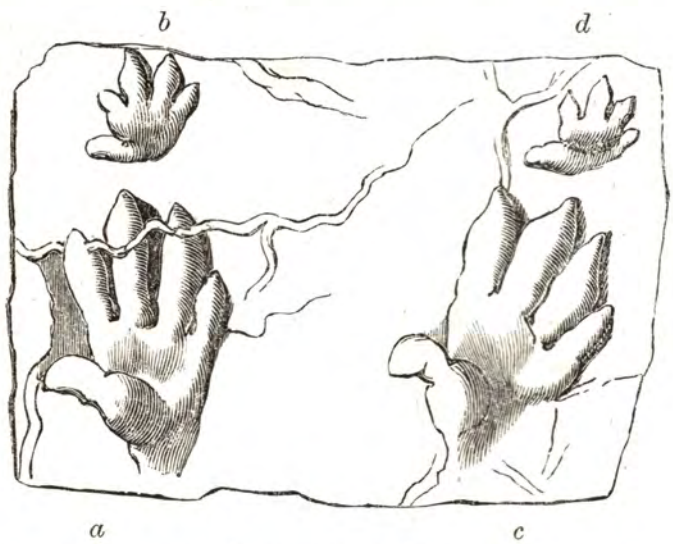
About twenty years since, much interest was excited by the discovery of footmarks, resembling those of land tortoises, on the exposed surfaces of slabs of Triassic sandstone, in a quarry at Corncockle Muir in Dumfriesshire, of which an interesting account was published by the Rev. Dr. Duncan. Regular tracks of footprints, indicating the slow progression of a small four-footed animal over the surface, while the stone was in the state of moist sand, were traced on the blocks of sandstone when separated in the lines of stratification by the quarrymen. In one instance there were twenty-four consecutive impressions, forming a track with six distinct repetitions of the marks of each foot, the front feet differing from the hind feet; the appearance of five claws was discernible on each fore paw. These foot-tracks most nearly resemble those made by land tortoises of a moderate size. Another discovery of footprints was soon afterwards made in strata of the same geological age at Hildburghausen, in Saxony; but these were evidently of very large unknown quadrupeds, in which the fore paws were much smaller than the hind ones. Subsequently, similar fossil tracks were observed on slabs of triassic sandstone in the quarries at Storton, near Liverpool. These foot-tracks are on the face of each successive stratum of sandstone, the cor-

[1] The following notice of the specimens is given in the British Museum Catalogue:—

"The slabs of sandstone on the north wall of this Room, with the supposed tracks of an unknown animal called Chirotherium, are,—that on the left, from the quarries of Hildburghausen in Saxony; and that in the centre, from those of Storton Hill, near Liverpool, (the latter presented by J. Tomkinson, Esq.) On the right hand are placed slabs from the same New Red Sandstone formation, with equally enigmatical impresses of various dimensions, called Ornithichnites, being very like footmarks of birds: they occur in the sandstone beds near Greenfield, Massachusetts, at a cataract in the Connecticut river, known by the name of Turner's Falls."

responding surface of the overlying stone presenting, in relief, casts of the imprints, and other markings. Some of the recently exposed slabs are covered with small hemispherical depressions or pits, produced by rain-drops that fell while the surface was soft and impressible.

CHIROTHERIUM.—The quadrupedal Ichnolites at Hildburghausen and Storton are of various kinds. Some appear to have been produced by crabs or other crustaceans, and by small reptiles; but the most remarkable imprints are those of large quadrupeds whose hind feet were nearly twice the size of the fore feet; a disproportion that prevails in certain marsupial mammalia, and in batrachian reptiles.



LIGN. 20.—CHIROTHERIUM FOOTPRINTS ON SANDSTONE. HILDBURGHAUSEN, SAXONY.
($\frac{1}{8}$ *nat. size.*)

a, *b*. Imprints of a hind foot and fore foot of the same animal.
c, *d*. Similar imprints of another individual on the same stone.

The two slabs of sandstone from Saxony (in the wall case) have well-marked tracks of similar footsteps, the surface of one exhibiting them in relief, or as casts, and the other in intaglio, or impressed. The hollow impressions of the feet are always on the *upper* surfaces of the slabs of stone, and the convex casts on the *under* side of each layer or stratum, the latter fitting closely into the former.

On a stone six feet long by five wide, there were the footsteps of several animals of various sizes. The largest imprints are generally eight inches long, and five wide. Near each large footmark, and at the distance of an inch and a half beyond it, is the imprint of the forefoot, which is but four inches long and three wide. These footsteps follow one another in pairs, each pair being in the same line, and fourteen inches in advance of one another. Each footmark has five toes, and the first or great toe is bent inwards like a thumb, and is alternately on the right and left side of both the large and small footprints, which, except in size, closely resemble each other.

M. Kaup, who first described these remarkable fossils, proposed the name *Chirotherium* for the unknown animal whose existence is indicated by these hand-like footmarks. No certain remains of the beings whose footsteps are the subject of these remarks have hitherto been discovered. There have, however, been obtained from the same deposits in Germany and England, skulls, teeth, and bones, of several species of an extinct genus of reptiles, supposed to be related to the Batrachians, or frog-tribe, and which have been named *Labyrinthodon*, from the peculiar character of the intimate structure of the teeth.[1] Some of these Saurians must have attained a magnitude equal to that indicated by the largest Chirotherium tracks, while other species corresponded in size with the lesser Ichnolites. There is, therefore, much probability in the conjecture that the Labyrinthodons were the originals of the hypothetical Chirotheria; but, unfortunately, the form and structure of the feet is unknown, for no bones of the extremities have been discovered; the presumed identity cannot, therefore, be determined, till more instructive specimens are brought to light.

ORNITHICHNITES. (*Footprints of Birds on stone.*)—*North Wall.*—The river Connecticut, in part of its course through the country which bears its name, and in the northern districts of the adjoining State of Massachusetts, flows through a valley formed of argillaceous sandstone, probably of the age of the Triassic formation, resting unconformably on the in-

[1] See "Wonders of Geology," p. 554.

clined edges of primary or palæozoic rocks. These deposits are traversed from north to south, through an extent of eighty or a hundred miles, by basaltic dykes, which have elevated the sandstone beds on the east, and partially overspread them on the west, the strata dipping in the latter direction at an angle of from 20° to 50°; successive layers of sandstone are thus exposed, and accessible along considerable tracts of country. From this circumstance, and from the facility of transport afforded by the proximity of the river, numerous quarries have, for many years, been profitably worked near the water's edge in various localities in the valley of the Connecticut. About fifteen years ago, attention was directed to numerous tracks of trifid imprints which appeared on the upper surface of the sandstone, with the corresponding figures in relief on the under face of the superincumbent layers, and which were thought to resemble the footsteps of gigantic birds. At length some well-marked specimens came under the notice of Dr. Deane of Greenfield, who communicated the fact to Professor Hitchcock (the President of Amherst College), and other naturalists, and the origin of these problematical appearances became a subject of earnest inquiry. Dr. Deane diligently collected specimens from various localities, and Professor Hitchcock scientifically worked out the subject, and in 1836 published the first account of these fossil footprints in the American Journal of Science. To this eminent observer is due the merit of having established, upon scientific grounds, the true nature of these enigmatical inscriptions on the Triassic rocks, and reduced a mass of vague observations and conjectures to a systematic arrangement of the phenomena in question.[1] The foot-tracks are, for the most part, tridactylous (three-toed); but many have a fourth toe directed backwards. Some resemble those made by the feet of small birds, others of birds of moderate size; the greater number, however, must have been made

[1] In England, Dr. Buckland was the first to admit the correctness of Professor Hitchcock's interpretation of the facts observed: see Bridgewater Treatise, 1836, vol. ii. p. 39. I must refer the reader for further particulars to "Wonders of Geology," p. 556. Dr. Deane (who first directed the attention of naturalists to the fact) has communicated several interesting memoirs to the American Journal of Science, and the Trans. Acad. Americ. The most complete and scientific memoir on the subject is that by Professor Hitchcock, in Trans. American Academy of Arts and Science for 1848, with numerous plates. See also Sir Charles Lyell's "Travels in the United States," vol. iii.

by bipeds much larger than the ostrich, or any known living types, and are comparable in magnitude with the footsteps of the extinct Moas of New Zealand, of which we shall treat in the next chapter. Tracks of small quadrupeds are oftentimes associated with those of the bipeds, and appear to be referable to reptiles—possibly of the batrachian order, and related to the Labyrinthodon, or Rhynchosaurus. The fossil footprints occur in many localities, extending upwards of eighty miles from north to south, and have been found in New Jersey and Pennsylvania. In general they are abundant wherever extensive explorations have been conducted in the laminated argillaceous sandstones. Dr. Deane states that the most perfect and distinct specimens have been discovered in the beds at "Turner's Falls," the northern termination of the sandstones.

SPECIMENS IN THE BRITISH MUSEUM.—It was from this locality that the three fine specimens affixed to the wall before us were obtained by Dr. Deane, of whom they were purchased by the Author for the Trustees of the British Museum,[1] and added to the collection in 1844. The foot-tracks are not confined to any particular beds, but are repeated through the entire series of strata, which in some places attains a total thickness of nearly 1,000 feet.

The laminated structure of the deposits indicates a slow and gradual accumulation of fine sediment, like the deposit of the mud of the Nile; and the period through which the same phenomena were repeated must have embraced thousands of years. But though the vertical extension of the tracks is so great, their horizontal distribution, so far as hitherto observed, is very limited. Professor Hitchcock states that they are generally restricted to a belt of rock only a few yards wide, and which seems to have formed the shore of an estuary; and that along this strand are the footsteps of all the animals that frequented that ancient shore.

I subjoin a figure of one of the small footprints, (*Lign.* 21,) to show that the structure of the toes is analogous to that in birds; the number of phalanges in the respective digits exactly corresponding; thus there are *three* in the great or inner toe, *a*; *four* in the middle, *b*; and *five* in the outer toe, *c*. The lobes apparent at the junction of the

[1] At the cost of £60.

three digits are produced by the distal extremity of the metatarsal bone: the hemispherical and circular spots with

LIGN. 21.—FOOTPRINT OF A TRIDACTYLE BIRD, AND IMPRESSIONS OF RAIN-DROPS, ON SANDSTONE. CONNECTICUT.
(*Nat. size.*)

which the surface of the stone is sprinkled, are the effect of rain, which must have fallen before the footprint was made.

The following is Dr. Deane's account of the specimens before us:—

"It is rare to find a stratum containing these foot-prints exactly as they were impressed by the animals; for they are usually more or less distorted and obliterated by the soft nature of the mud, the coarseness of the materials, and other circumstances, which have partially defaced them; so that although the general form of the foot may be apparent, the minute traces of its appendages are almost invariably lost. In general, distinct evidence of the peculiar phalangeal structure of the toes of birds is wanting, and each toe appears to be formed of a single joint, without the terminal claw. But a few specimens have been discovered in which the true charac-

ters of the foot are clearly developed, with its rows of phalanges, and its claws, and integuments. So far as my observations extend, the sharpest impressions are on the shales of the finest texture, with a smooth glossy surface, such as would retain the impressions of rain-drops (as in *Lign.* 21). The layers of stone do not often present this kind of surface; but recently I have discovered a stratum containing in all more than one hundred most beautiful impressions of the feet of four or five varieties; the whole surface having also been pitted by a shower of rain. The impression of a medallion is not more sharp and clear than are most of these imprints; their remarkable preservation may probably be ascribed to the circumstance that the surface of the stratum was incrusted with a layer of micaceous sandstone, which adhered so firmly that it could not be removed without the laborious and skilful application of the chisel. The appearance of this glossy layer, which is of a grey colour, while the slab is of a dark red, seems to indicate that it was washed or blown over the latter while in a state of loose sand; thus filling up the foot-prints and rain-drops, and preserving them unchanged in the smallest particular; the form of the nails or claws, and joints, and the deep impressions of the distal extremity of the tarso-metatarsal, or shank-bone, being exquisitely displayed. The great slab (*Lign.* 22), which is about six by eight feet in dimensions, and two inches in thickness, contains above seventy-five impressions. There are five rows of the species called by Professor Hitchcock *Ornithichnites fulicoides*,[1] of five and six foot-marks each; three rows of the medium size, of four imprints each; one row of the small size, of fourteen consecutive imprints; besides several others, ranging from two to six impressions each. It is worthy of remark, that of these numerous footprints, with but one or two exceptions, two or more nowhere occur on the same spot."

The direction and disposition of these footsteps on the largest stone are shown in *Lign.* 22; and lines are drawn from one imprint to another in the course of the consecutive tracks, to render the illustration more intelligible. The principal tracks on this slab are as follow; viz.—

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[1] *O. fulicoides*, so named from the resemblance to the footprints made by the recent Cinereous Coot (*Fulica Americana*). See "Trans. American Geologists," p. 259, 1 vol. 8vo. Boston, 1843.

Fig. 1 to 1, directed from below upwards, is a track consisting of six large footsteps.
2 to 2, from above downwards; a track of four footprints, disposed almost in a right line, and very far apart.
3 to 3, a track of five footprints, from above downwards, of a large, heavy bird, like fig. 1.
4 to 4, from above downwards, four footprints like fig. 2, disposed in a nearly straight track, and far apart.
5, a track of five heavy footprints, directed obliquely upwards.
6 to 6, five footprints of a large bird, in a track from below upwards.
7, a series of five delicate footprints.
8 to 8, a track of eleven very small footprints, disposed in zigzag, and extending obliquely from the right extremity to the upper edge of the slab.
9 to 9, a track of four large and distant footprints, passing obliquely across the stone from left to right.

This description will suffice to convey a general idea of the nature of these extraordinary remains.

A few shapeless fragments of bones are the only vestiges of the skeletons of any animals, with the exception of fishes, that have been found in the strata which have furnished the slabs of Ornithichnites; but some coprolites have been discovered, which, from a chemical analysis, are supposed to have belonged to omnivorous birds. The enormous size of some of the foot-marks are calculated to excite much surprise. I have in my possession (through the kindness of Dr. Deane) imprints that prove the size of the foot in one species to have been fifteen inches in length, and ten inches in width, exclusively of the hind claw, which is two inches long. The footprints of this bird, when in a consecutive series of five or six, are from four to five feet apart, which must have been the length of the stride of the bird; the longest stride was probably made by the animal when running; the shortest, when walking at a moderate pace. These footsteps indicate proportions so far exceeding those of all known living bipeds,—for the foot of the African Ostrich is but ten inches long,—that geologists hesitated to adopt the opinions of the American naturalist, in the absence of any relics of the osseous structure of the supposed birds, although sanctioned by the high authority of Dr. Buckland, who, from the first, concurred in the views of Professor Hitchcock; and I candidly confess my incredulity, until a series of specimens sent to me by Dr. Deane, accompanied with a graphic description of the circumstances connected with their position in the

strata, brought conviction to my mind. Professor Hitchcock's last memoir on this subject embraces figures, and descriptions of footprints, which he considers as referable to twelve kinds of quadrupeds; viz.—four probably Saurians, two Chelonians, and six Batrachians. The bipedal imprints belong to eight species of thick-toed tridactylous birds; fourteen to narrow-toed tridactylous or tetradactylous species; two are probably of bipedal batrachians; and eight are not determinable.

I have described the bipedal imprints as those of birds, in conformity with the opinion entertained by the most eminent observers, who have carefully investigated the phenomena on the spot.

Impression of the skin of the toes. — Unfortunately, the footprints very rarely exhibit any traces of the structure of the dermal integument, or skin, a character which would yield important evidence as to the reptilian or ornithic relations of the original. It may, therefore, be interesting to state that on a slab collected by Dr. Deane, and presented to me, there are two or three foot-marks with distinct impressions of the skin of the under surface of the toes; and this structure appears to resemble that of the Ostrich.[1]

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[1] This specimen is in my possession; the following note from Dr. Deane accompanied it:—

"The slab is about two feet in diameter, and half an inch in thickness. On the upper surface there are two rows of small elegant foot-marks, of the species termed by Professor Hitchcock *Ornithichnites gracillimus;* one row consists of five, and the other of six consecutive impressions. There is also a row of four footprints of a much larger species, the *O. fulicoides.* These are arranged around the circumference of the specimen, and their alternate order proves that they have been impressed by the same individual. *There is a rare peculiarity displayed in these larger impressions that adds greatly to their interest; it is the markings of the papillæ, and folds of the cutaneous integument, which are very distinct; and this character I have only observed in two other examples.* The papillæ may be seen most distinct in the first, second, and fourth footstep; particularly in the last of the series, on the top of the slab. The three tracks embrace fifteen impressions, and exhibit the articulations of the toes perfectly. The surface of the stone is pitted by rain-drops, from a shower which must have fallen before the birds walked over the soft mud, and made the foot-prints. There are also indistinct traces of the trails of worms, and of an Annelide. On the reverse of the slab there are the casts of four consecutive impressions of *Ornithichnites gracillimus;* and a row of two, of dimensions intermediate between those of the preceding varieties."

But although the weight of evidence is in favour of the ornithic character of these footsteps on the sands of Time, the idea of such a development of the highly organized class *Aves*, during the Triassic epoch, is so utterly at variance with what is known as to the existence of warm-blooded, air-breathing vertebrata on the lands of the secondary formations, that until bones of birds are discovered in strata of the same age, we would repeat the salutary caution of an eminent palæontologist: — "Footprints alone, like those termed Ornithichnites, are insufficient to support the inference of the progression of the highly developed organization of birds of flight, by the creatures that have left them. The Rhynchosaurs, and the biped Pterodactyles, already warn us how nearly the ornithic type may be approached without the essential characters of the Saurian being lost; and by the Cheirotherian ichnolites we learn how closely an animal, in all probability a batrachian, may resemble a pedimanous mammal in the form of its footprints." [1]

Notwithstanding, therefore, the presumptive proofs lately obtained of the ornithic origin of the footsteps on the Connecticut sandstones, I do not think we are warranted in concluding, in the absence of all vestiges of the skeletons of the animals, that the countries of the Triassic epoch rivalled the islands of New Zealand, in the abundance, variety, and magnitude of that highly organized class, of which no certain relics are known in formations of a much later period.

Sir C. Lyell on Ornithichnites.—I will conclude this notice of a subject involving questions of such deep interest, with the following extract from the admirable address of the late President of the Geological Society, which embodies the most recent observations and opinions of that eminent philosopher on the phenomena in question.

"When I first examined these strata of shale and sandstone near Jersey city, in company with Mr. Redfield, I saw at once from the ripple-marked surface of the slabs, from the casts of cracks, the marks of rain-drops, and the imbedded fragments of drift-wood, that these beds had been formed precisely under circumstances most favourable for the recep-

[1] "Brit. Assoc. Report on Fossil Reptiles," 1841, p. 203.

tion of impressions of the feet of animals, walking between high and low water. In the prolongation of the same beds in the valley of the Connecticut, there have been found, according to Professor Hitchcock, the footprints of no less than thirty-two species of bipeds and twelve of quadrupeds. They have been observed in more than twenty localities, which are scattered over an area of nearly eighty miles from north to south in the States of Massachusetts and Connecticut. After visiting several of these places, I entertained no doubt that the sand and mud were deposited on an area which was slowly subsiding all the while, so that at some points a thickness of more than 1,000 feet of superimposed strata had accumulated in very shallow water, the footprints being repeated at various intervals on the surface of the mud throughout the entire series of superimposed beds.

"When I first examined this region in 1842, Professor Hitchcock had already seen 2,000 impressions, each of them indented on the upper sides of layers of shale, while the casts of the same, standing out in relief, always protruded from the lower surface of the incumbent strata. Had they been concretions, as some geologists at first contended, they would have been occasionally found projecting from the upper sides of strata of sandstone. I was also much struck when following each single line of foot-marks, to find how uniform they were in size and how nearly equidistant from each other, whereas on turning to a larger or smaller set of impressions, the distance separating any two tracts in the same series immediately increased or diminished, there being an obvious proportion between the length of the stride and the dimensions of the creature which walked over the mud.

"There are also a great number of examples where the trifid impressions exhibit three marks of phalangeal bones for the inner toe, four for the middle, and five for the outer one, as in the feet of living tridactylous birds, and in each continuous line of steps the three-jointed and five-jointed toes are seen to turn alternately right and left. In one slab found at Turner's Falls, on the Connecticut, by Dr. Deane, the fine matrix has retained marks of the integument or skin of the foot. This specimen is now in the museum of Dr. Mantell, and the impression was recognised by Prof. Owen as resembling the skin of an ostrich, and not that of a reptile. Such

a test, in addition to the other evidence before mentioned, should, I think, remove all scepticism in regard to the ornithic nature of most of these bipeds. The size indeed of some of the fossil impressions seemed at first to raise an objection against their having belonged to birds, as it far exceeded that of any living Ostrich; but the Dinornis and other feathered giants of New Zealand have removed this difficulty.

"The footprints are accompanied by numerous coprolites, and Mr. Dana has derived an ingenious argument from the analysis of these bodies, the proportion they contain of uric acid, phosphate of lime, carbonate of lime, and organic matter, showing that, like guano, they are the droppings of birds rather than of reptiles.[1] Still it is asked, whether, if birds were so abundant, we ought not to meet with some of their bones in a fossil state,—a remark, be it observed, which is equally applicable to the associated quadrupedal imprints. In reference to this question, I took pains, when on the shores of the Bay of Fundy, after I had examined the red sandstone of the Connecticut, to inquire whether, in digging trenches through the red mud of recent origin, from which the tide has been excluded by sea-banks, they had ever found the bones of birds, and I could hear of no instance, although I saw the sandpiper, or *Tringa minuta*, making every day those lines of impressions in the mud bordering the estuary which I have described and figured in my 'Travels.'[2] My friend Dr. Webster, of Kentville, Nova Scotia, has recently sent me some fine examples of rain-drops, which he saw formed during a shower on this modern mud, and casts of which project in relief from the under-side of an incumbent layer of the same argillaceous deposit, thrown down during a subsequent rise of the tides. Thus marked and traversed by cracks caused by shrinkage, and containing the footprints of birds, they present a perfect counterpart of many of the old triassic shales above described."[3]

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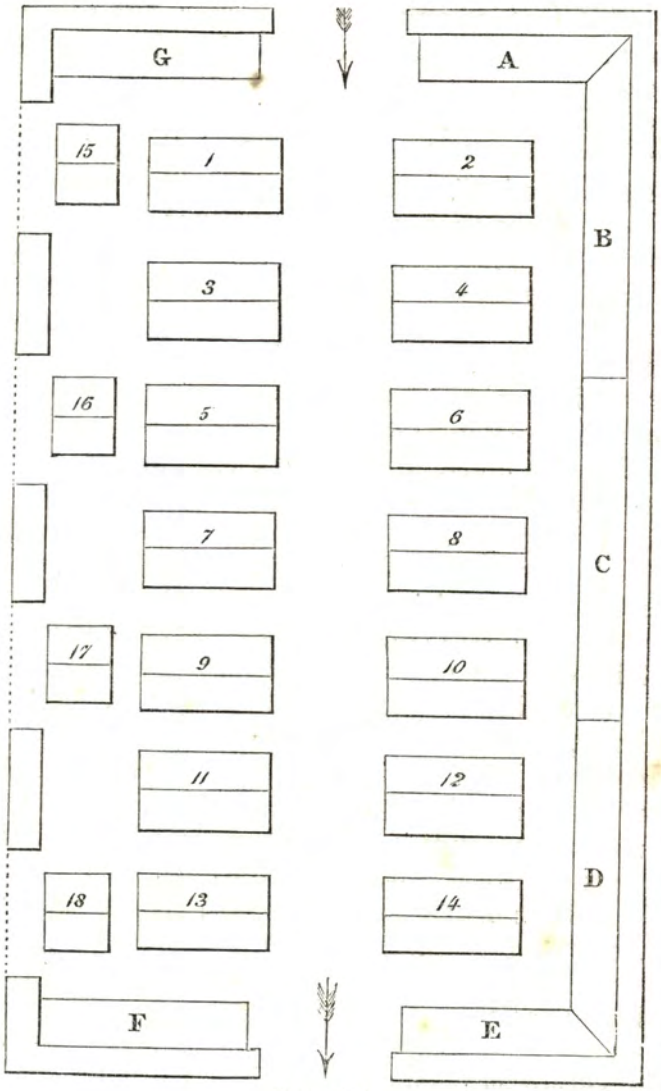
[1] "Amer. Journ. of Science," vol. xlviii. p. 46.

[2] Sir Charles Lyell has presented specimens of the foot-tracks of these birds on the sandy shores of the Bay of Fundy to the British Museum, for comparison with the fossils.

[3] Sir C. Lyell's Anniversary Address, pp. 44, 45.

PLAN OF ROOM II.

Entrance from Room I.



Room III.

CHAPTER II.

Part I.

PLAN OF ROOM II. — SYNOPSIS OF CONTENTS OF ROOM II. — MAMMALIAN REMAINS — MEGALONYX — MOA — HEXAPROTODON — MYLODON — MACRAUCHENIA — SCELIDOTHERIUM — MEGALOCHELYS — STARFISHES — CRINOIDEA — MINERALS — FOSSIL BIRDS OF NEW ZEALAND.

The arrangement of the objects in the apartment we shall next survey is but temporary; some of the cases are empty, and others contain fossil remains of Mammalia, Birds, and Reptiles; and of Starfishes, and Crinoidea. The subjoined synopsis will therefore suffice to direct the visitor to the specimens most worthy of attention in this miscellaneous collection, and our descriptions will embrace but two classes of objects, namely,—the fossil Starfishes and Crinoidea in Case *G*; and the remains of the Moa or Dinornis, and other extinct birds of New Zealand, contained in Wall-cases *B* and *C*, and Table-cases 15, 16, and 17. The latter comprise relics of several extraordinary ornithic types, presenting osteological characters previously unknown in animals of this class, and which demand minute examination; while the geological history of the deposits in which these bones were contained invests the subject with a high degree of interest and importance.

ROOM II.

(62 *feet long.*)

Synopsis of Contents.

ORGANIC REMAINS.

Wall-Cases.—These are only partially filled, and the arrangement is but provisional. Those on the left, or south side, contain a miscellaneous assemblage of bones and teeth

of Mammalia and Reptiles, and many bones of colossal Birds from New Zealand.

A. [1.] Bones of Mammalia from the drift and alluvial deposits of England. Among them are teeth of Elephants, Horses, Deer, Ox, &c. (collected by the Author), from the strata overlying the Chalk along the Sussex Coast, between Brighton and Rottingdean. The ungueal bone, cannon or metatarsal bone, and teeth, of an extinct species of Horse (*Equus fossilis*), imbedded in masses of conglomerated pebbles from the ancient shingle bed, are especially worthy of notice.[1]

Near these fossils are several bones (of a bluish black colour, from phosphate of iron) of a Deer, discovered in the alluvial silt of Lewes Levels.

B. [2.] *Megalonyx.*—On a shelf on the upper part of this case there is a series of models of bones of the *Megalonyx*, a colossal extinct Edentate mammalian; the originals were discovered in the celebrated Mammoth Cave, in Kentucky, United States.[2]

Moa or *Dinornis.*—On the upper shelves of this case, to the right of the above specimens, are many bones of the extremities, and several pelves, of extinct colossal birds from New Zealand, called *Moa* by the natives, but more generally known by the scientific name, DINORNIS. All these specimens were collected by Mr. Percy Earle, from the submerged deposit at Waikouaiti, on the eastern shore of the Middle Island, which will hereafter be particularly described. The enormous size of some of these bones cannot fail to arrest the visitors' attention: a tibia, or leg-bone, in this collection is one of the largest known, and indicates a bird eleven or twelve feet high.

C. [3.] On one of the shelves is placed the anterior portion of the upper and lower jaws, with teeth, of an enormous *Gavial*, from the Eocene deposits of the Sewalik Hills.

Skulls with teeth, and other bones of Mammalia, and por-

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[1] See "Medals of Creation;—Excursion to Brighton Cliffs," vol. ii. p. 913.

[2] Originally in the Author's Museum; presented by Dr. Morton, of Philadelphia. An interesting account of a late exploration of this remarkable cave, by Prof. Benjamin Silliman, Jun., and Mr. Reginald N. Mantell, is given in the "American Journal of Science" for May, 1851.

tions of the carapaces of Chelonian reptiles, from the same strata, presented by Major Cautley and Dr. Falconer, are also deposited in this case. Among the former are specimens of the *Hexaprotodon*, an animal allied to the Hippopotamus, and characterised by the presence of six incisor teeth in each jaw : hence the generic name.

Mylodon.—There are likewise bones of colossal Edentata, from the Pampas of South America : the skull and bones of *Mylodon Darwinii* (so named in honour of Charles Darwin, Esq.) are particularly interesting.

D. [4.] *Macrauchenia.*—In this compartment are bones of the *Macrauchenia Patachonica*, an extinct Pachyderm, as large as a Rhinoceros, uniting characters connecting it with the Camel and Palæotherium, from Patagonia; presented by Charles Darwin, Esq.

In the same case are the skull, vertebræ, scapula, humerus, femur, and other bones of the *Scelidotherium* (*S. leptocephalum*), an extinct Edentate related to the *Mylodon :* from South America ; collected and presented by Mr. Darwin.[1]

E. [5.] This case is filled with the remains of the carapace, plastron, &c. of several individuals of the *Megalochelys Atlas;* a stupendous fossil tortoise, discovered by Major Cautley and Dr. Falconer in the Eocene strata of the Sewalik Hills ; with the bones of Mastodons, Elephants, &c., to be described in the sequel. A model of a young individual, constructed by Mr. Dew, is placed near the entrance of Room I., and is described *ante*, p. 11. Some of these relics show that the length of the carapace was upwards of twelve feet in adult specimens.

F. [6.] This case is unoccupied.

G. [7.] *Stelleridæ.*—On the right of the entrance. This case is assigned to fossil Starfishes and Crinoidea. Some of the Starfishes and *Marsupites* from the chalk of Sussex, on the right-hand shelf, are unusually perfect.

Pentacrinites.—In the centre of this cabinet there is affixed to the wall a slab of Lias limestone, about five feet square, from Bohl in Wirtemburg, on which is disposed in relief a

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[1] As these Mammalian Remains will probably be removed to Room VI., it will be convenient to notice them more particularly when treating of the contents of that apartment.

group of *Pentacrinites*, upwards of thirty in number, in the most graceful attitudes, as if the creatures were sporting in their native element: a matchless specimen.

Apiocrinites.—In the lowermost compartment there are choice examples of the *Bradford Encrinite* (*Apiocrinites Parkinsoni*), collected by the late Channing Pearce, Esq. A recent *Pentacrinus caput medusæ* from the West Indies, is placed in this case for comparison with the fossil remains. On the right-hand shelf are fossil Starfishes of the genera *Asterias, Goniaster, Amphiura, Comatula*, &c.

Lily Encrinite.—On the left there are examples of various genera of Crinoidea, viz. *Eugeniacrinites, Cyathocrinites, Apiocrinites* (*A. Prattii*, from the Author's collection), *Encrinus Townsendi;* and of the beautiful Lily Encrinite (*E. liliiformis*), from the Muschelkalk of Brunswick.

On the uppermost shelf are some fine specimens of casts of Crinoideal stems (commonly called screw or *pulley-stones*), in chert; from the mountain limestone of Derbyshire.

MINERALS.

TABLE CASE 1.—[54.] Contains the sulphates of lime. Selenite or sparry gypsum, from Montmartre, Bex, Oxford, &c.; anhydrite; bardiglione; and tripe-stone, a fibrous compact variety.

On the table near the window, beneath a glass shade, there is a remarkably fine group of selenitic crystals, from Reïnhardsbrunn, Saxe Coburg: presented by his H. R. H. Prince Albert.

2. [7.] Sulphuret of copper, copper glance, or vitreous copper.

In this case are specimens of the so-called "Frankenberg corn-ears," which are fossil vegetables mineralized by vitreous and grey copper; sulphuret of copper and iron; copper pyrites; variegated copper ore; Tennantite.

3. [53.] Sulphates of barytes and strontian. Celestine, &c.

4. [8.] Sulphuret of lead or galena.

5. [52.] Nitrates and sulphates. Sulphates of baryta or heavy spar; Bolognese spar; ketten-spaths or chain-spar, from the Hartz; cawk, of Derbyshire; hepatite or fetid baroselenite; wolnyne, from Muzsay in Hungary.

6. [9.] Sulphurets of bismuth, of copper and bismuth, of copper and tin, or tin pyrites.

The remainder of this case is filled with sulphuret of mercury, or cinnabar.

7. [51.] Green carbonates of copper. Fine and rare varieties of malachite; compact malachite, from the Ural Mountains.

8. [10.] Sulphuret of silver; common silver glance, massive, crystallized, &c. Sulphurets of antimony.

9. [50.] Carbonates of copper; copper azure, &c.

10. [11.] Simple and double sulphur salts, formed by the sulphurets of antimony or arsenic, with basic sulphurets of electro-positive metals. Jamesonite; geocronite; kobelite; boulangerite; zinkenite; silver-blende, red or ruby silver, &c.; bournonite; polybasite.

11. [49.] One half is occupied by carbonate of zinc or zinc-spar; calamine. The other half contains carbonates of lead or lead-spar; carbonate of bismuth; rare carbonates of cerium; of yttria on orthite from Ytterby, Sweden.

12. [12.] Grey copper or fahl-ore. Sulphurets of arsenic; yellow and red orpiment; arsenio-sulphurets.

13. [48.] Brown spar. Carbonate of iron; carbonate of manganese, crystallized and in globular and botryoidal shapes, of various shades of rose colour, on sulphuret of manganese, &c.

14. [13.] Oxides and hydrous oxides of manganese.

*** There is one table of minerals, near the north-east window, not labelled.

The four following tables in this room stand parallel with the windows, and are numbered consecutively from east to west.

ORGANIC REMAINS.

TABLE CASES 15, 16, 17. *Fossil Birds of New Zealand.*—These three cases contain a fine series of vertebræ, bones of the extremities, &c., dug up by Walter Mantell, Esq., of Wellington, from a bed of volcanic sand (*menaccanite*), on the west coast of the North Island of New Zealand, near the mouth of the river Waingongoro.

15. Among the interesting relics in this case the visitor should notice the *femur*, *tibia*, and *fibula* of the same young individual of one of the most gigantic species of *Moa*. The bones of the hind limbs in this case belong to several species of birds, and are in a remarkably perfect state.

16. Contains the only known skull of a most extraordinary type of bird, which is referred to the genus *Dinornis:* the other cranium, with mandibles approaching somewhat in configuration to those of the Cassowary, is the generic type of *Palapteryx*.

In this case are the skull, and bones of the sternum, wings, and legs, of the *Notornis Mantelli*, of which genus the only known recent example has lately been obtained by Mr. Walter Mantell. (*See Frontispiece of this Volume.*)

There are also tarsometatarsals of a remarkable extinct genus named *Aptornis:* bones of a species of *Nestor*, and of the

existing *Apteryx;* and portions of *egg-shells* of three distinct kinds of birds, which were dug up with the fossil bones.

Other remarkable objects in this case are a femur or thigh-bone of a Dog: the only relic of a terrestrial mammalian found in the most ancient ossiferous deposits; and calcined bones of Men, Moas, and Dogs, that were dug up by Mr. Walter Mantell from the ancient fire-heaps of the natives, at Waingongoro.

17. A fine series of vertebræ, and tarsal, and phalangeal bones, of various species and genera of Birds, from the same locality.

18. This table-case has been removed since the plan was engraven.

*** The intelligent attendant to whose surveillance Rooms I. and II. are entrusted, is Mr. Saunders, who has for many years been attached to this department of the British Museum.

Rooms II. and III. are superintended by Mr. Thomas Priestley.

Rooms IV. and V. are under the custody of Mr. Lingard.

Rooms V. and VI. are taken charge of by Mr. Davies.

The civility and intelligence of these officers, and their obliging attention to me on all occasions, I am gratified in having this opportunity of acknowledging; and I may add, that the visitor, desirous of examining any particular specimen, will have no difficulty in accomplishing his object by application to the attendant of the Room in which it is contained.

CHAPTER II.

Part II.

FOSSIL STELLERIDÆ — STARFISHES — CRINOIDEA — ENCRINITES — PULLEY-STONES—MARSUPITES—APIOCRINITES—LILY ENCRINITE—PENTACRINITES—PETREMITES.

Fossil Stelleridæ.—*Wall-Case G.*—Under this name are comprised two groups of radiated animals; namely, the *Asteridæ*, or Starfishes, and the *Crinoideæ*, or Lily-shaped zoophytes, of which there are specimens of many species and genera in the case to which I would now direct attention.

The zoophytes, popularly called *Starfishes*, from their stellular forms, are so generally diffused through the seas surrounding our Island, that the common five-rayed Asterias must be familiar to every one, and will serve as an illustration of the general appearance and structure of the beings whose petrified remains are the subject of examination. This species belongs to the division in which the rays are elongated and far exceed in length the diameter of the disc; in another group (the Cushion-stars), the body is angular, and the lobes or rays are short, and not longer than the diameter; while in a third subdivision (*Comatula* and *Ophiura*), the arms are distinct from the body, and elongated and articulated, as in the *Crinoideæ*.

The external surface of the common Starfish is soft, and attached to a tough coriaceous integument, investing a skeleton composed of numerous calcareous ossicula, arranged in regular series along the margins of the rays. Each ray has a longitudinal furrow or groove, perforated at the sides by alternating rows of pores through which tubular tentacula are protruded. The mouth is situated in the centre of the under

surface. Now, if we imagine a Starfish placed with its mouth upwards and the five rays fringed with long articulated tentacula, and fixed by the centre of its dorsal surface upon a jointed stem, we shall have the essential characters of a Crinoidean; and the animals of one recent genus of *Asteridæ* are actually in this condition in the earlier stage of their existence: these are the *Comatulæ*, or Feather-stars.[1]

From the importance of the Crinoideæ in the economy of the ancient world, the history of this only crinoideal type at present inhabiting the European seas, which once swarmed with these beautiful creatures, presents many points of interest to the naturalist. The receptacle of the soft body of the *Comatulæ*, like that of the crinoideans, consists of a cup-shaped calcareous base, which sends off from its margin five arms, that quickly subdivide, and are beset on each side with rows of articulated pinnæ; on the convexity there are also numerous slender-jointed simple tentacula. The mouth is situated in the centre of the area surrounded by the arms, and is capable of being elongated. In the young state, the Comatulæ are attached by a jointed stem to other bodies.[2] The stem is composed of about eighteen joints, which are pentangular. After a few weeks the Feather-star becomes detached from its peduncle, and ranges the sea in freedom.

Four fossil species of Comatula have been discovered in the Solenhofen slate; and it is not improbable that some of the numerous Crinoideans may be species of this genus in the early stages of development.

In another group of Asteridæ (named *Ophiura* or Serpent-stars) the rays are long and slender, and without grooves or tentacula, and are distinct from the body. These organs are extremely flexuous, and in some species beset with spines, and enable the animal to seize and entwine round its prey. There are several fossil Ophiura from the lias in this Case.

Goniaster.—These Starfishes are of a pentagonal form, and bordered by marginal plates; several fossil species occur in the white chalk, and in this collection there are some beautiful

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[1] The reader interested in this subject should peruse the elegant and charming volume on British Starfishes and other Echinoderms, by Professor Forbes. 1 vol. 8vo. John Van Voorst. 1841.

[2] See "Medals of Creation," p. 333.

examples from Sussex and Kent. The chalk-flints often have remains of Goniasters attached to the surface; in the neighbourhood of Northfleet, specimens of this kind of great beauty have been collected.[1]

CRINOIDEA.—*Encrinites* and *Pentacrinites.*—*Wall-Case G.* —The Crinoideæ have a fixed pedicle or process of attachment, an articulated stem composed of numerous separate pieces of a solid calcareous substance, and a receptacle formed of a series of plates, to the upper margin of which are attached arms or tentacula. They consist of two groups; one with smooth, subcylindrical stems—the *Encrinites;* the other in which the stems are pentangular—*Pentacrinites.*

The fossil remains of the Crinoideæ have received the name of *Stone-lilies*, from the resemblance of the receptacle of some species when the animal is in a state of repose to a closed lily or tulip. Only one living species is known, namely, the *Pentacrinus Caput-Medusæ*, an inhabitant of the Caribbean Sea, of which there is a specimen at the bottom of this Case. This animal has a long jointed stem, which is fixed at its base by a pedicle or root-like processes, and supports a vase or receptacle, formed of a series of calcareous plates closely adjusted to each other, in which the viscera are contained. The upper part of the receptacle is covered by a plated integument, in which there is an opening for the mouth. From the brim or margin, proceed ten multiradiate arms, which subdivide into branches of extreme tenuity; the upper and inner side of the arms support numerous articulated *cirri*, or feelers. The ossicula composing the column of support are pentangular, very numerous, and articulated by striated pentapetalous surfaces, and have a central perforation; and there are articulated side-arms, or tentacula, that radiate from the column in groups of five, at different points. In a living state the skeleton is covered by the integuments which secrete it; the mouth is situated in the centre of the plated integument of the receptacle, and surrounded by the arms, which, when spread out, with their numerous *cirri*, form a net for the capture of the prey, and are the organs by which it is conveyed to the mouth.

The fossil remains consist of the ossicula, or bones of the

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[1] "Pictorial Atlas," Pl. LIII. figs. 1 and 3.

column, arms, and tentacula; of the plates of the receptacle; and of the peduncle, or process of attachment by which the animal was permanently fixed to the rock. The peduncle is in some species flat and expanded, like that of the *Gorgoniæ;* in others, it consists of long jointed processes. These several parts are commonly found detached, and intermingled with detritus in the strata; throughout extensive beds of encrinital marble, vestiges of the receptacle are but seldom discoverable. In some localities the skeletons are preserved entire, and spread out on the surface of the layers of shale, clay, or limestone, as if the animals had been enveloped by the soft deposit when alive in their native seas, as is the case in many of the beautiful specimens before us.

These remarks will convey a general idea of the nature of the beings whose remains are scattered through certain rocks in such inconceivable quantities; for, much as the columns may differ in form, the ossicula in their markings, and the plates of the receptacle in their configuration and ornament, the same type of structure prevails throughout the family.

These durable parts of the animal fabric occur in immense quantities in the ancient secondary deposits; and in many parts of England, and of northern Europe and America, entire mountain-chains are chiefly composed of the bones and detritus of *Crinoideæ*, belonging to numerous extinct species and genera.

Screw or *Pulley-stones.—Upper Shelf F.*—The circular, or pentagonal channel formed by the united ossicula of the column, has given rise to the curious fossils called, in Derbyshire, *Screw*, or *Pulley-stones*, which are flint casts of these cavities. These bodies occur in the chert, which is interstratified with the mountain limestone; the siliceous matter, when fluid, having filled up the channels, and invested the calcareous stems: the latter have since been dissolved, and consequently solid cylinders of flint, resembling a pulley, alone remain; the masses of chert are often impressed with the ornamented articulating surfaces of the ossicula, or trochites. These fossils are sometimes mineralized by galena, or sulphuret of lead, as in the specimens in this cabinet.

In the quarries on Middeton Moor, near Cromford, Derbyshire, where extensive beds of limestone composed of crinoideal remains are worked for chimney-pieces, and other ornamental

purposes, beautiful examples of these fossils may be obtained. The cavities of the columns and ossicula are often filled with white calcareous spar; while the ground of the marble is of a dark reddish brown colour. In other varieties of the Derbyshire entrochal limestones, the substance of the fossils is white, and the ground dark grey or brown; both kinds, when worked into ornaments, are very beautiful and interesting.[1]

MARSUPITES (*M. Milleri*).—*Wall-Case G. On the upper and right-hand Shelf.*—The chalk fossils labelled Marsupites in the upper compartment of this cabinet belong to an interesting extinct type of Stelleridæ, that forms a connecting link between the Starfishes and the Crinoideans. Like the former, it is free, and destitute of a column of support or pedicle; while it has the receptacle composed of articulated plates, and flexible arms, as in the lily-shaped animals. These fossils are peculiar to the white chalk deposits, and were first described by Mr. Parkinson in the "Organic Remains of a Former World," under the name of "Tortoise Encrinite," that excellent observer having supposed, from the sculpturing of the plates of certain specimens, that they were related to the Actinocrinites, and had a jointed column. The true characters of the original were first pointed out in my "Fossils of the South Downs;"[2] and the name *Marsupites*, suggested by the purse-like form of the closed specimens, was adopted.

The receptacle of the Marsupite is of a subovate shape, rounded and entire at the dorsal aspect, consisting of a large central plate, and a series of polygonal plates, with five arms attached to the margin. The opening of the receptacle was covered by an integument supported by numerous small semilunar ossicula, in the centre or side of which the buccal aperture, or mouth, was placed. The external surface of the receptacle is smooth in some examples; in others it is deeply sculptured with granulated lines and furrows, disposed in a radiated manner; and in a few instances the sculpturing is rugous and irregular. The Marsupites vary in size from one to three inches in length. The receptacle is very capacious

[1] "Pictorial Atlas," Pl. XLIX. for figures of pulley-stones and encrinital marbles: and Pl. XLVII. for representations of a great variety of stems of Encrinites and Pentacrinites.

[2] "The Fossils of the South Downs," or "Illustration of the Geology of Sussex," p. 184, pl. xvi.

compared with that of the Crinoideæ. The central plate is large and of a pentagonal form, without the slightest trace of a process of attachment: five pentagonal pieces are united to the sides of the central plate, and above these a like number of hexagonals, which receive the five upper plates that form the margin; each of the latter has a semilunar depression to articulate with the first joint of the arm.

Detached plates and ossicula of marsupites are not uncommon in the chalk of Kent and Sussex; nearly entire receptacles, filled with chalk or flint, are occasionally found in the pits near Lewes and Brighton; but examples with remains of the arms are extremely rare; and I have seen but one specimen (the one in the Case before us, which I collected from the Sussex chalk), in which the plates of the integument that covered the opening of the receptacle are preserved.[1]

Apiocrinites. (*A. Parkinsoni.*)—Pear-Encrinite of Bradford. —*Wall-case G.*—The "Pear-Encrinite," from its size, and the abundance of its remains in one particular locality, is the most generally known of all the British fossil Crinoideæ. It abounds in the beds of oolite, especially in the quarries on the heights above the picturesquely situated town of Bradford, in Wiltshire. The receptacle, detached ossicula, and the pedicles or roots, are very common; and in some instances the entire skeleton from the peduncle to the extremities of the arms, is met with. The late Channing Pearce, Esq., of Bradford, by unremitting attention to the collecting of these fossils, obtained the beautiful specimens deposited in this Case.

This Apiocrinite has a smooth receptacle of a pyriform shape, composed of large plates with radiated articulating surfaces; the stem is short and strong; the arms simple, resembling those of the marsupite; the peduncle spreads out into an expanded base, which is firmly attached to the rock, like that of the Gorgonia, and is generally of a rich purple colour.[2] Sir Charles Lyell mentions an interesting fact relating to the occurrence of these fossils in the oolite strata at Bradford. In Bur-

[1] See "Medals of Creation," p. 319, Lign. 70; "Pictorial Atlas," Pl. XLVI., fig. 24; "Wonders of Geology," p. 652.

[2] See "Wonders of Geology," p. 653; "Pict. Atlas," Pl. L.

field quarry, on the heights that overlook the town, a bed of limestone was exposed, the upper surface of which was incrusted with the stony peduncles or roots of Apiocrinites; upon this stratum was a layer of clay, in which were innumerable remains of receptacles and ossicula of stems and arms; some of the stems were erect, others prostrate, and throughout the clay were the dismembered remains. This submarine forest of Crinoideans must therefore have flourished in the clear sea-water, till invaded by a current loaded with mud that overwhelmed the living zoophytes, and entombed them in the argillaceous deposit in which their fossil remains are embedded.

Lily Encrinite. (*Encrinus liliiformis.*) *Wall-case G. Left upper Shelf.*—This exquisite species of Crinoidea is equally interesting and attractive to the amateur collector and the naturalist. Its remains do not occur in the British strata, and are only known in the muschelkalk of Lower Saxony. The specimens in this country are chiefly from Erkerode, in Brunswick; they are found in a layer about eighteen inches thick, of a soft argillaceous cream-coloured limestone, which is chiefly made up of trochites, (*i.e.* detached ossicula of the stem), and a few fragile shells and corals.

The receptacle of the Lily Encrinite is smooth, and in the form of a depressed vase; its base is composed of five plates, upon which are placed three successive series of other plates, with the uppermost of which the arms articulate. The stem is formed of numerous perforated round ossicles, articulated to each other by radiated grooved surfaces, and becoming somewhat pentangular, and alternately larger and smaller towards the summit, to which the receptacle is fixed; a construction admitting of great freedom of motion.

This Encrinite when lying in relief on the rock, with its receptacle entirely or partially closed, so strikingly resembles a bud or expanding flower of a lily or tulip, as to justify the popular name of Stone Lily. An exquisite specimen is figured by Mr. Parkinson.[1] There are a few beautiful examples in the Case before us.

Pentacrinites.—*Wall-case G.*—In this group of Crinoideans the ossicles of the columns are angular, generally pentagonal,

[1] See "Pictorial Atlas," Pl. XLVIII.; "Wonders of Geology," p. 651.

but occasionally with only four angles; in some species the sides are acute, in others rounded: the articulating surfaces are for the most part richly chased with floreal or radiated striæ, and grooved.[1] The arms in some species are very long and greatly subdivided, becoming extremely attenuated, and the ossicula proportionably minute. The exquisite beauty of the plumose encrinites when expanded on slabs of limestone and petrified by pyrites, is exemplified in several examples in the Case under review.[2]

LIGN. 23.—PENTACRINITES HIEMERI; PART OF A GROUP ON LIAS LIMESTONE, FROM BOHL, WIRTEMBURG.[3]

($\frac{1}{6}$ *Nat. size.*)

PENTACRINITES HIEMERI.—*Wall-Case G.*—On the large slab of Lias limestone affixed to the wall in the centre of this Case, is an exquisite group of thirty Pentacrinites, exposed in relief on the surface of the stone, in as perfect a state as if just

[1] "Pictorial Atlas," Pl. XLVII. The Briarean Pentacrinite is fully illustrated and described in detail in Dr. Buckland's Bridgewater Essay, p. 484.

[2] "Pictorial Atlas," Pl. LI. LII.

[3] This species was named and figured by M. Konig in his "*Icones Fossilium sectiles*," Pl. III., fig. 29, in 1826.

dredged up from the bottom of the sea. The reduced sketch of a small portion will serve to convey an idea of the elegant forms of these petrified zoophytes of the Jurassic ocean; the contemporaries of the Ichthyosauri and other marine reptiles, of which we shall treat hereafter. The Pentacrinites on this slab are for the most part entire; the peduncle being affixed to the base, and the column extending upwards in gentle undulations, and supporting the receptacle, which has the arms gracefully outspread in various attitudes. The structure of the receptacle, and of the arms, and the extreme delicacy of the finer tentacula made up of countless minute ossicula, are admirably shown in this unique and most instructive specimen.

This Case also contains illustrative examples of the *Actinocrinites* (Nave Encrinite),[1] *Cyathocrinites* (Cup Encrinite),[2] *Eugeniacrinites* (Clove Encrinite), and several other genera.

Pentremites.—One peculiar type of Crinoidea requires a brief notice, as it was supposed to be without arms, and to form a connecting link between the lily-shaped zoophytes and the sea-urchins. The *Pentremites* has a receptacle supported by a short pedicle, and composed of polygonal plates, divided by five perforated grooves or furrows, which are of an elongated petalous form, and converge in a rosette on the summit. The marginal longitudinal rows of minute pores are not however for the passage of soft membranous feelers, as in the ambulacra of echinoderms, as was formerly conjectured, but are channels for the transit of vessels that supply an infinite number of delicate simple tentacula, composed of extremely minute calcareous ossicula, as in the other Crinoidea, but not subdivided as in the Pentacrinites and Encrinites. These tentacula are directed upwards towards the vertex of the receptacle, and are supposed to have been organs for seizing and conveying food to the mouth.[3]

These Crinoideans abound in the mountain limestone, especially in some districts of the United States, where certain strata are distinguished by the name of pentremital limestone.[4]

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[1] "Medals of Creation," p. 324. [2] Ibid. p. 326.

[3] See Dr. Fred. Roemer on Jointed Tentacles found on the ambulacral spaces of *Pentremites*, "Geol. Journal," vol. v. p. 8.

[4] "Medals of Creation," p. 327.

CHAPTER II.

Part III.

THE FOSSIL BIRDS OF NEW ZEALAND.

FOSSIL REMAINS OF BIRDS—MOA OF NEW ZEALAND—NATIVE TRADITIONS—HISTORY OF THE DISCOVERY—GEOLOGY OF NEW ZEALAND—MOA-BED AT WAIKOUAITI—OSSIFEROUS DEPOSITS IN THE NORTH ISLAND—BONE CAVES—FLORA AND FAUNA OF NEW ZEALAND—THE APTERYX—MOA, OR DINORNIS—CRANIUM—BONES OF EXTREMITIES OF DINORNIS—FOOT OF DINORNIS—PALAPTERYX—CRANIUM—FOSSIL EGGS OF DINORNIS—APTORNIS—FOSSIL BONES OF NOTORNIS—DISCOVERY OF A LIVING NOTORNIS—FOSSIL PARROT—APTERYX—ALBATROSS—PENGUIN—DOG—SEALS—BURNT HUMAN BONES—RETROSPECTIVE SUMMARY.

Fossil remains of Birds. — Before describing the specimens which form the immediate subject of the present section, I would offer a few general observations on the occurrence of the remains of Birds in a fossil state, as introductory to the interesting phenomena that will shortly engage our attention.

Relics of birds are of extreme rarity in the mineral kingdom; throughout the immense series of palæozoic and secondary formations, the accumulated deposits of innumerable ages, no unquestionable indications of the existence of this class of highly organized beings have been brought to light.

Triassic Epoch.—In the Triassic or New Red argillaceous sandstones of the Valley of the Connecticut River, the remarkable foot-tracks described in a previous chapter, and of which there are illustrative examples in Room I. (*ante*, p. 13), seem to render it highly probable that birds of great size, and referable to numerous species and genera, existed during the period when the Triassic strata of the

United States were deposited; but, unfortunately, notwithstanding the preponderance of the evidence in favour of the ornithic origin of these mysterious imprints on the rocks, the only certain proofs—remains of the skeleton—are still wanting: no bones of animals of a higher class than fishes and reptiles having been discovered.

Oolitic and Wealden Epochs.—In the vast fluviatile formation, the Wealden of the South-East of England, which abounds in the remains of terrestrial plants and reptiles, numerous fragments of bones of such tenuity as to show that they belonged to animals capable of flight, have from time to time been collected, since my discovery and announcement, in 1822, of the occurrence of supposed bones of birds in the strata of Tilgate Forest. Some of the bones in my collection were regarded, by Baron Cuvier, and subsequently by other eminent anatomists, as unquestionably those of birds; one specimen especially was conceived to be decisive of the question, for Professor Owen supposed it to be the tarso-metatarsal of a wader, with the oval cicatrix for the attachment of the hind toe; but this fossil ultimately proved to be the distal end of a humerus.

Later observations have shown that it is probable all the presumed ornithic remains from the Wealden belong to Pterodactyles, as well as those from the oolitic strata of Stonesfield. The microscopic examination of some of the thin cylindrical bones from each of these formations, by Mr. Quekett and Mr. Bowerbank, has, however, revealed a structure which these gentlemen regard as exclusively ornithic.

Cretaceous Epoch.—In the Chalk formation many osseous remains of animals capable of flight, as indicated by the articulations, and the extreme tenuity of the walls of the bones, have been obtained from Burham quarries, near Maidstone. Some of these specimens have been figured and described by Professor Owen as those of a bird allied to the Albatross, under the name of *Cimoliornis Diomedeus*;[1] but the occurrence in the same strata of the skull, jaws with teeth, and other unquestionable bones of gigantic Pterodactyles, and the absence, in the fossils, of osteological characters exclusively

[1] "British Fossils, Mammals, and Birds," p. 545; and Dixon's "Fossils of Sussex," p. 403.

ornithic, support the conclusion that these also must be ascribed to flying reptiles.

The enormous size of the bones, however, indicating an expanse of ten or twelve feet from the extremity of one wing across to that of the other, and suggesting the idea of a flying reptile equal in magnitude to the fabled Roc of Arabian story, threw doubts on the pterodactylian nature of these remains; but Mr. Bowerbank has lately obtained from the same quarry portions of an upper jaw with teeth, so large, that the head of the creature to which it belonged could not have been less than sixteen or seventeen inches in length;[1] a size proportionate to that of the bones of the extremities above alluded to.

But although no certain vestiges of birds have yet been discovered in the Wealden or Cretaceous formations, I think there are good reasons for supposing that such remains will sooner or later be brought to light: for independently of the ornithic structure detected by the microscope, I had from the Wealden a portion of an *ulna*, on which there was a row of distinct eminences, as in birds, for the attachment of the large wing-feathers; this specimen was in the collection purchased by the Trustees of the British Museum.

Tertiary Epoch.—In the most ancient tertiary strata, bones of several genera of birds occur; in the Sub-Himalayan deposits they are associated with relics of the extinct proboscidean mammalia of India: in those of the Paris Basin, with remains of Palæotheria, &c. From the miocene and pliocene lacustrine deposits of Auvergne, bones, and even egg-shells, of several kinds of aquatic birds have been obtained.

The ossiferous caverns which abound in the bones and teeth of numerous carnivora, often contain the remains of existing genera of birds. In the Cave of Kirkdale, Dr. Buckland discovered bones of species of raven, pigeon, duck, lark, snipe, &c.[2]

The fossil bones of birds, however, even in the most recent deposits, were of such rare occurrence, as to be ranked by the

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[1] Described by Mr. Bowerbank under the name of *Pterodactylus giganteus*. Proceedings of the Zoological Society.

[2] See "Reliquiæ Diluvianæ," p. 34; "Medals of Creation," *Art.* "ORNITHOLITES," p. 795.

collector of organic remains among the most precious of his acquisitions : until a few years ago, when a most extraordinary discovery in New Zealand astonished and delighted the palæontologist, by placing before him hundreds of bones of extinct genera of birds, some of which must have far surpassed in stature the most gigantic living biped—the Ostrich.

THE MOA OF NEW ZEALAND.—*Native Traditions.*[1]—In various districts of New Zealand there had been occasionally observed in the beds of the mountain-torrents and rivers, bones of several kinds of birds, of almost incredible magnitude.

The Maoris, or natives, were acquainted with the occurrence of such bones long ere the country was visited by Europeans ; and traditions were rife among them that a race of gigantic birds formerly existed in great numbers, and served as food to their remote ancestors. They also believed that some of the largest species had been seen alive within the memory of man, and that individuals were still existing in the unfrequented and inaccessible parts of the country. They called the bird MOA, and stated that its head and tail were adorned with plumes of magnificent feathers, which were worn and much prized by their ancient chiefs as ornaments of distinction. The bones were sought for with avidity, and were used in the manufacture of lures for fish-hooks, and other implements.

The first European who appears to have taken cognizance of these facts, and paid attention to the native traditions on the subject, was the intelligent and active missionary, the Rev. W. Colenso, who in a journey to the East Cape District with the Rev. J. Williams, had his curiosity strongly excited by the accounts given by the natives of the prodigious

[1] The following account of the Fossil Birds of New Zealand comprises the substance of a *Lecture* delivered by the Author before the BRITISH ASSOCIATION OF SCIENCE *at Edinburgh*, August 5th, 1851. The history of the discovery is drawn up from various sources ; principally from the letters of my eldest son, MR. WALTER MANTELL, of Wellington, who has resided in the colony upwards of eleven years : the geological facts are entirely the result of his personal observations. The anatomical descriptions, and the determination of the zoological characters and relations of the various species and genera, are chiefly abstracts of the valuable "*Memoirs on the Dinornis*, &c.," by PROFESSOR OWEN, in the "*Zoological Transactions*," vols. iii. and iv.

size and strength of the *Moa*, which they affirmed was still living; and they alleged in proof of the accuracy of their statements, the enormous bones occasionally discovered in the neighbouring river-channels. After much labour and research, Mr. Colenso at length procured a few specimens, and subsequently a considerable number were collected by the Rev. W. Williams, a masterly account of which was drawn up by the former gentleman, and published in the Tasmanian Journal.[1]

HISTORY OF THE DISCOVERY.—In November, 1839, British naturalists were first made acquainted with the discovery of bones of colossal ostrich-like birds in New Zealand, by the fragment of a thigh-bone of a bird much larger than that of the Ostrich, which had been brought to England by a Mr. RULE, who lent the specimen to Professor Owen, by whom it was described in the "Zoological Transactions." This bone was part of the shaft of a femur, with both extremities wanting; it was about six inches in length, and five and a half inches in its smallest circumference. From the form and structure of this fragment, it was inferred that it belonged to a struthious bird, heavier and more sluggish than the Ostrich, with thighs and legs shorter and thicker; its proportions more nearly resembling those of the Dodo, than of any of the existing Struthionidæ. "The discovery of this relic of a large struthious bird in New Zealand," observes Professor Owen, "is one of peculiar interest on account of the remarkable character of the existing fauna of that island, which still includes one of the most extraordinary and anomalous genera of the order—the *Apteryx;* and because of the close analogy which the event indicated by the present relic offers to the extinction of the Dodo of the islands of the Mauritius and Rodrigue."[2]

In Dr. Dieffenbach's "Travels in New Zealand," (1843,) under the article *Apteryx Australis*, there is the following notice:—"To this order (Struthionidæ) probably belongs a bird, now extinct, called *Moa* or *Movie* by the natives. The

[1] See Appendix A. *Mr Colenso's Memoir.*

[2] "Zoological Transactions," Vol. III. Part I. It is much to be regretted that this first specimen was not preserved in the College of Surgeons; but Mr. Rule informed me the purchase of it was declined, and he afterwards sold it for 3*l.* to Mr. Bright, of Bristol.

evidences are a bone very little fossilized, which was brought from New Zealand by Mr. Rule to Mr. Gray, and by him sent to Professor Richard Owen. I possess drawings of similar bones, and of what may possibly be a claw of the same bird, which are in the possession of the Rev. R. Taylor, of Waimate. They were found on the east coast of the North Island, and were brought down by rivulets from a neighbouring mountain called Hikorangi."[1]

In 1843, a collection, comprising vertebræ, and bones of the hinder extremities, pelvis, &c., were transmitted by the Rev. W. Williams to the Dean of Westminster, (Dr. Buckland;) and in 1846 many specimens were sent to England by Dr. Mackellar, Mr. Percy Earle, and Colonel Wakefield. These were placed in the hands of Professor Owen, and form the subject of his first and second "Memoirs on the Dinornis," in the "Zoological Transactions," Vol. III., in which the genera Dinornis, Palapteryx, &c., were established.

In 1846 and 1847, my eldest son, Mr. Walter Mantell, of Wellington, who had resided several years in the colony, explored every known locality of these fossil bones within his reach, in the North Island; and went into the interior of the country, and located with the natives, for the purpose of collecting specimens, and of ascertaining whether any of these gigantic birds were still in existence; resolving, if there appeared to be the least chance of success, to penetrate into the unfrequented regions, and obtain a live Moa. The information gathered from the natives offered no encouragement to follow up the pursuit, but tended to confirm the idea that this race of colossal bipeds was extinct; the last individuals having, in all probability, like the Dodo, been exterminated by human agency, within a comparatively recent period: or that if any of the species whose bones occur in a fossil state are still living, they will prove to be of comparatively small types related to the Apteryx, the living diminutive representative of the stupendous ostrich-like birds which once trod the soil of New Zealand.

My son succeeded, however, in forming the most interesting collection of these remains hitherto obtained. It comprised between seven and eight hundred bones belonging to birds of

[1] "Travels in New Zealand," vol. ii. p. 195.

various species and genera, and differing considerably in magnitude and age; some belonging to very young individuals in which the epiphyses of the long bones are distinct from the shaft; while others are those of adult and aged birds. The chief part of this collection is deposited in the *Table-Cases* 15, 16, 17.[1]

Geology of New Zealand.—The fossil bones of birds from New Zealand, in the British Museum, have been obtained from two localities, which are several hundred miles distant from each other; one being in the North, and the other in the South Island; and the deposits in which they occur differ considerably in their geological and mineralogical character.

As the interest of these fossil remains is intimately connected with the physical conditions under which they were deposited, we will first briefly explain the geological structure of the country, and afterwards describe the localities whence the bones were obtained.

New Zealand is situated in the South Pacific Ocean, lying between the thirtieth and fiftieth degrees of south latitude, and forming a group of three mountainous islands, which in their aggregate extent equal that of England and Wales. Its geological structure is with difficulty determined, owing to the primeval forests which fringe the coasts; and where these have been destroyed by ancient conflagrations, by impenetrable thickets of esculent ferns. The fundamental rock is clay-slate, and this is frequently traversed by greenstone dykes, as at Port Nicholson, Queen Charlotte's Sound, and Cloudy Bay.

On the banks of the rivers Eritonga, Waibo, and along some parts of the sea-coast, there are horizontal terraces of trap-boulders fifty feet high. Anthracite crops out in the harbour of Wangarua; and there is a seam of the same mineral intercalated in the sandstone on the east shores of the North Island.

The coasts are in many places skirted by recent horizontal sediments, consisting of loam with fragments of wood and fern, &c. The small rocky islets of trachyte off the coast of

[1] This collection was purchased by the Trustees of the British Museum for 200*l*. See Appendix B. *Mr. Walter Mantell's Collection.*

the Northern Island, bear marks of wave-action to the height of 100 feet above the present sea-level. In the interior of this island there is a lofty central group of volcanic mountains, some of the cones being still in activity; the ancient lava-streams appear to have been erupted from the base of the craters. The highest mountains are Tongariro, which is estimated at six thousand feet in height, and Mount Egmont, at nine thousand feet: the summits are covered with perpetual snow. There are many lakes which appear to occupy extinct ancient craters. Earthquakes are not unfrequent, and of late years some have occurred of unusual violence, from which the town of Wellington suffered considerably.

The comparatively modern terraces of loam and gravel which stretch along the coasts at an elevation of from fifty to one hundred feet above the sea, attest that great changes in the relative level of land and water have taken place at no very distant period. The existing rivers of New Zealand almost everywhere cut deeply through accumulations of volcanic detritus which in some places contain birds' bones; and these beds are here and there covered by marine and fresh-water deposits of very modern origin. All these phenomena indicate the oscillations to which the land has recently been subjected.

In the Middle Island, according to my son's observations, as in the Northern, the lowermost visible rocks are clay-slate and metamorphic schists, intersected by dykes of greenstone, and compact and amygdaloidal basalt; and in some places there are intruded masses of obsidian, and other volcanic products. Hornblende and porphyritic rocks, gneiss and serpentine occur; but granite has not been observed.

Mountain ranges of schistose and metamorphic rocks extend through the country, from near Cloudy Bay on the north-east, to the south-western extremity of the Island, a distance of between three and four hundred miles; their crests everywhere attain an elevation above the line of perpetual snow,—hence they were named the Southern Alps by Captain Cook. These hills are flanked by volcanic grits, and covered at their base by alluvial deposits, that have evidently originated from the decomposition of trachytic rocks and earthy lavas.

No active volcanoes are known in the Middle Island, nor have any extinct craters been discovered: but as the physical

structure of the interior of the country, and especially of the Alpine districts, has been but imperfectly explored by Europeans, no conclusive inferences can be drawn from this negative evidence.

Beds of limestone, composed of organisms similar in their generic types to those which prevail in certain cretaceous strata of Europe, appear in a few places along the eastern coast, from near Morakura to Kakaunui: but their relation to the adjacent plutonic and metamorphic rocks has not been ascertained.

A pleistocene, or modern tertiary blue clay, abounding in shells of species existing in the neighbouring ocean, overlies the limestone at Onekakara; and is in many places covered by alluvial deposits of gravel, sand, conglomerate, and loam, which form the superficial soil of the vast plains that are spread over the eastern side of the central mountain-chain. On the western shore of the North Island, beds of clay with similar fossil shells occur beneath the ossiferous deposits, as we shall presently have occasion to notice.

In many places there are alluvial plains of loam, clay, and gravel, overgrown by ancient forests; and extensive mud and sand-flats, formed by the existing streams and rivers, at their embouchures, and in their tortuous course from the mountain ranges whence they take their rise, till they reach the seashore.[1]

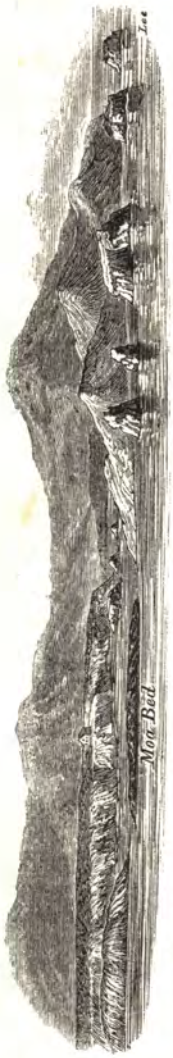
Ossiferous Deposit at Waikouaiti. The fossil birds' bones in the Wall-case *B*, were collected by Percy Earle, Esq.[2] and like those transmitted to England by Dr. Mackellar, and the late Col. Wakefield, are for the most part of a dark brown colour, strongly impregnated with tannin, and more or less permeated by phosphate and carbonate of iron; they resemble in their appearance and state of mineralisation, the bones of the Irish Elk, Mastodon, and Mammoth, &c. dug up from peat-bogs and morasses. They were obtained from a submerged swamp, visible only at low water, that is situated

[1] See "Memoirs on the Geology, and Fossil Remains of Birds of New Zealand, from Notes and Observations by Walter Mantell, Esq." "Geological Journal," Vol. IV. Part I. and Vol. VI. p. 319.

[2] This collection was purchased of Mr. Percy Earle by the Trustees of the British Museum, for 130*l*. Many of the specimens are figured and described in "Zoological Transactions," Vol. III. pp. 313—319.

on the south-eastern shore of the Middle Island. The following account of this locality is extracted from Mr. Walter Mantell's notes :—

"Near Waikouaiti, seventeen miles north of Otago, there is a headland called Island Point, about three quarters of a mile in length and 150 feet in height; it consists of sandy clay, distinctly stratified, and traversed by dykes of columnar trap, the columns being at right angles to the sides of the veins. In a little bight south of Island Point, on the side of the bar which unites that headland to the mainland at the entrance of the river Waikouati, in front of the native Kaika, named Makuku, is situated the exposed part of the so-called turbary deposit, whence bones of Moas and other birds of various kinds, have been obtained in such number and perfection. This bed is about three feet in depth and not more than a hundred yards in length, and lies immediately on a stratum of tertiary blue clay; its inland boundary is obscured by vegetation, and appears to be of very limited extent; the bed is entirely submerged, and only visible when the tide has receded.



LIGN. 24. MOA-BED AT ISLAND POINT, WAIKOUAITI, EAST COAST OF THE MIDDLE ISLAND OF NEW ZEALAND.
(Sketched on the spot by Walter Mantell, Esq.)

"It consists almost wholly of decayed vegetable matter, and its surface is studded with the undisturbed roots of small trees which appear to have been burnt to the ground at some remote period. It is a light, sandy, elastic earth, of a blackish brown colour, and emits a strong fetid odour when first collected, from the large quantity of animal matter it contains. I conceive it was originally a swamp or morass, in which the New Zealand flax (*Phormium tenax,*) once grew luxuriantly. It is now covered by a thin layer of sand when exposed at low water.

"The above sketch of the coast, (*Lign.* 24,) will serve to illus-

trate the position of this remarkable ossiferous deposit of the colossal birds of New Zealand. The appearance and condition of the bones are similar to those of mammalia imbedded in peat-bogs. They have acquired a rich umber colour, and their texture is tough and firm; they contain a large proportion of animal matter, even the periosteum is in some instances preserved.

"Although bones of several species of Moa, especially of the largest kinds, have been collected from this locality in considerable numbers and in great perfection, yet as the bed is rapidly diminishing from the inroads of the sea, there is great reason to fear that it will be entirely washed away, without yielding to the palæontologist all the desired information respecting the extinct animals whose relics it enshrines; for the natives and whalers are well aware of the interest attached to the bones by Europeans, and they seize indiscriminately on any specimen exposed by the receding tide, and if it cannot be readily extracted they break it off, and thus many a valuable relic has been destroyed. Their cupidity and avarice have too been so much excited by the large rewards injudiciously given by casual visitors, that the cost of specimens has increased to an unreasonable amount."

An earnest of the invaluable treasures that might be obtained by careful research, is afforded by the entire series of bones (26 in number) of a pair of feet and legs of the largest species of Moa (*Dinornis robustus*), that were found standing erect, the one about a yard in advance of the other, with the proximal ends of the two shank-bones just visible above the soil. These were carefully extracted bone by bone, and ticketed on the spot by my son, so that I was enabled to have them articulated as in a recent skeleton; and they now constitute an unique example of the bones of the feet found in natural connexion, and show the original form and structure of these organs in the extinct colossal birds of our Antipodes.[1] From the position of these bones, there can be no doubt, as my son observes, that the unfortunate Moa was mired in the swamp, and unable to extricate itself, perished on the spot:

[1] The frontispiece of the "Pictorial Atlas," is a beautiful lithograph of one of these feet by Mr. Dinkel, one-third nat. size. See pp. 10—12 of that work.

in like manner as the groups of Irish Elks occasionally found in England, and the mammoths and mastodons in the bone-licks or ancient swamps of America.

OSSIFEROUS DEPOSIT IN THE NORTH ISLAND. The bones collected by my son from the North Island (deposited in the *Table-cases*, 15, 16, 17,) present a very different appearance from those of Waikouaiti above described. Instead of being heavy and of a dark colour, and permeated by silt and iron, they are light and porous, and of a delicate fawn-colour ; the most fragile processes are entire, and the articulating surfaces of the joints smooth and uninjured ; even portions of egg-shells, and mandibles, and the bony rings of the tracheæ or air-tubes, are preserved.

In their general aspect these bones resemble those of the carnivora from the ossiferous caverns of Germany. Their state of preservation is evidently due to the material in which they were imbedded, which is a loose volcanic sand (termed *menaccanite*) containing titaniferous iron, crystals of horn-blende and augite, &c, the detritus of volcanic rocks and earthy tuff. The sand has filled all the cavities and cancelli that have external openings, but is in no instance consolidated or aggregated together ; it is easily removed by a soft brush. The following extract from my son's letter, dated Wellington, June, 1847, details the circumstances under which this most interesting collection was formed :—

"On the western shore of the North Island, about sixty miles south-west of New Plymouth, there is a stream called Waingongoro, which empties itself into the sea at about a mile and a half south of Waimate in the Ngátirúanúi district. Part of the neighbouring country is elevated table-land, with deep tortuous gullies, through which the torrents and streams take their course to the sea. That of Waingongoro, which is as tortuous as any of them, takes its rise in the neighbouring volcanic ridge, and has evidently at a former period discharged itself far distant from its present embouchure, as is proved by the existence of a line of cliffs which extends inland, and has manifestly been produced by the corroding action of the river. Driven from its course, probably, by a change in the relative level of the land and sea, the stream has formed its present channel, which cuts through a bed of loose conglomerate, 100 feet thick, over-

lying a deposit of finely laminated sand, which covers a thick stratum of blue clay full of shells. The conglomerate consists of pebbles and large boulders of an infinite variety of volcanic rocks; the clay is the lowermost visible bed; the shells it contains are marine, and resemble species existing in the South Pacific Ocean; but I suspect many will be found specifically distinct from any recent forms.

"Between the two bluffs near the embouchure of the river, there is a sand-flat, about 200 yards across, and this on my first visit was strewn with bones of *men, moas and other birds, and two species of seals.* I had some deep openings made near the foot of the ancient cliff, on the top of which is the Pa, or native village of Ohawetokotoko; and at the same level as the flat on which I had observed the strewn fragments of bones, I came to a regular ossiferous deposit. The bones, however, though perfect, were as soft and plastic as putty, so that if grasped strongly they changed as it were by magic into pipe-clay, and it was necessary to dig them up with great care, and expose them to the air and sun to dry, before they could be packed up and removed.

"Unfortunately the natives soon caught sight of my operations, and came down in swarms,—men, women, and children,—trampling on the bones I had carefully extracted and laid out to dry, and seizing upon every morsel exposed by the spade. My patience was tried to the utmost, and to avoid blows, I was obliged to retreat and leave them in the possession of the field; and to work they went in right earnest, and quickly made sad havoc. No sooner was a bone perceived than a dozen natives pounced upon it, and began scratching away the sand, and smashed the specimen at once. It was with great trouble, and by watching the opportunity of working in the absence of the Maoris, that I procured anything worth having.

"The natives told me, and their assertion was borne out by the appearance of the place, that within their memory the entire area had been covered by drift-sand; in fact the bones seemed always to be imbedded on or beneath an old surface level. Columns of vertebræ, when the sand was carefully removed, were lying in situ and perfect, with, in rare instances, the skull and pelvis; but to preserve these precious

relics was impossible while beset by the hordes of Maoris and I could neither bribe nor drive them away.

"The largest femur, tibia, and fibula, (in Table-case 15) were lying in their natural connexion, the leg slightly bent at the knee: a chain of vertebræ of corresponding size was discovered near them, and I doubt not the whole belonged to the same colossal bird.

"Mixed with the bones, but exceedingly rare, were the fragments of the egg-shells. I also found six oval rings and one broad circular ring of tracheæ. In coming down from Ngamotu, I discovered a few more remains of egg-shells: one fragment is four inches long, and affords a chord by which to estimate the size of the original; as a rough guess, I may say that a common hat would have served as an egg-cup for it: what a loss for the breakfast table! And if native traditions are worthy of credit, the ladies have cause to mourn the extinction of the Moa: the long feathers of its crest were by their remote ancestors prized above all other ornaments; those of the White Crane, which now bear the highest value, were mere pigeon's feathers in comparison.

"The Maoris informed me that the sand-flat at *Te Rangatapu* was one of the first spots on which their ancestors located; and this seems not improbable, for in digging in various places I found small circular beds of ashes, with charcoal and bones, very ancient, and such as are generally left by the native fires that have long been burning on the same place. They contained calcined bones of men, dogs, and moas. Fragments of obsidian, flint, two fishing-line stones, and a whalebone *meri* (a sort of weapon), were also dug up."

Ossiferous Caves in New Zealand.—In a later communication, my son mentions having seen stalactites from limestone caves, which were said to contain moas' bones in their sparry floors, but he had not been able to visit them. This account proved to be correct, and I am indebted to the kindness of Dr. Andrew Smith, Inspector-General of the Army Medical Department, for the following notice by Dr. A. S. Thompson, Surgeon of the 58th Regiment:—

"During the month of September (1849), Servantes, the interpreter to the General here, was told by a native that he had discovered a cave in which were many bones of moas.

I accompanied him in search of this place, and was rewarded by getting many curious specimens, and several skulls with mandibles. The beak very much resembles that of the Ostrich or Emeu.

"This cave is on the west side of the North Island, in the limestone formation which extends along the coast. The country around is wild, and there are many similar caves, which, we were told, also contained bones. The popular opinion is that the country has been set on fire by an eruption of Tongariro, and that all the moas fled to the caves for refuge, and there perished. From traditions and other circumstances, it is supposed that the present natives of New Zealand came to these islands not more than 600 years ago. However this may be, that the Moa was alive when the first settlers came is evident from the name of this bird being mixed up with their songs and stories. One of the bones I obtained bore marks of having been cut or chopped, perhaps to get at the marrow."[1]

Fauna and Flora of New Zealand.—Before entering upon the examination of the relics of the extinct bipeds of the Islands of the South Pacific, let us briefly consider the characters of the existing fauna and flora, which are as peculiar and remarkable as those we are endeavouring to decipher from their fossil remains.

New Zealand at the present time offers the most striking example of a now acknowledged fact in every department of natural history, namely, that different areas of dry land are endowed with peculiar forms of animal and vegetable existences; they are centres, or foci of creation, so to speak, of certain organic types. And this law, with whose effects through countless ages, geological researches have made us familiar, appears to have continued in unabated energy to the present time.

Dr. Dieffenbach has the following remarks on this subject:—

"Although in its flora New Zealand has some relationship with the two large continents between which it is situated, —America and Australia,—and even possesses some species identical with those of Europe, without the latter being

[1] Letter to Dr. Andrew Smith, dated Auckland, October, 1849.

referable to an introduction by human agency, yet the greater number of species, and even genera, are peculiar to the country. In fact, New Zealand, with the adjacent islands, Chatham, Auckland, and Macquarrie, form a botanical centre, which is sufficiently distinct from both continents to preserve its peculiarities: and it offers in this respect the most striking instances of the fact, that different regions of the earth are endowed with peculiar forms of animals and vegetables.

"The number of species of plants at present known is about 650; of which 320 are dicotyledonous, and the remainder monocotyledonous and cellular, the latter very largely predominating. The grasses have given way to the ferns; for ferns, and fern-like plants, are the most numerous in New Zealand, and extend over immense districts. They hold the same place here as do the grasses in other countries. Some of the arborescent ferns grow to upwards of thirty feet in height; and the variety and elegance of their forms, from the minutest species to the giants of their kind, are most remarkable." [1]

But the fauna of New Zealand is yet more extraordinary. Instead of quadrupeds constituting a prominent feature in the zoology of these islands, they are almost entirely wanting; even of the cold-blooded class,—the reptiles,—a few diminutive forms are the sole representatives. Of the mammalia, there is but one known animal that can with certainty be regarded as an indigenous species, namely, a frugivorous rat; and which has rapidly diminished in numbers since the introduction of that universal pest, the Norway rat.

The natives affirm there is another indigenous terrestrial quadruped, which they call "*Kāurĕhe:*" but no specimen has been seen by the English colonists.[2]

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[1] Dr. Dieffenbach's "New Zealand."

[2] The *Kāurĕhe.*—My son, in his "Notes on the Middle Island," has the following remarks on this subject:—

"About ten miles inland of Arowenua Bush there is a lake where an indigenous terrestrial quadruped, called *Kaurehe,* is said to exist; another reported habitat of this animal is inland two days' journey from Te Taumutu. The *Kāurĕhe* is the only indigenous quadruped, besides a species of *Rat,* that there are any reasonable grounds for believing to have been known to the Maoris before the advent of Europeans.

With this solitary exception, the warm-blooded vertebrata of these islands exclusively belong to the class Aves, or Birds, of which there are upwards of fifty genera, comprising numerous species, and some very peculiar types: of these the well-known *Apteryx* (*Kiwi-kiwi* of the Maoris) is the most remarkable.

Apteryx (*Ap. Mantelli.*)—This genus comprises three known species, all of which are restricted to the Islands of New Zealand. It is referred by ornithologists to the group or family of *Struthionidæ*, or brevipennate birds, the anterior extremities being quite rudimentary in all the species.

The largest kind (*Ap. Australis*) is equal in bulk to a small turkey; the second species (*Ap. Owenii*) is smaller, and measures eighteen inches in total length; the third species (*Ap. Mantelli, Lign.* 25) is of an intermediate size. The colour of the common species is of a greyish chestnut; the

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The native descriptions, though vague and fanciful on some points, still appear to be founded on facts. The first account I obtained was as follows:—'Maopo, headman at Te Taumutu, states that the Kaurehe lays eggs as large as those of the duck.' (This suggested to me the idea of the Ornithorhynchus.) 'Our forefathers used to catch them, and keep them as pets: when they broke loose, as they frequently did, they would return to the place they had been taken from. They still exist a day and a half's journey inland. We are afraid of them. There are two kinds,—one living on the land; the other is amphibious.'

"From Tarawata, the principal person at the Umukaha, and who is descended maternally from the Ngatimanu (the first settlers in the Middle Island, and who were exterminated by the Ngaitahu) I received a more definite account. He informed me that the length of the animal is about two feet from the point of the nose to the root of the tail; the fur grisly brown—thick short legs—bushy tail—head between that of a dog and a cat—lives in holes—the food of the land kind is lizards, of the amphibious kind, fish—does *not* lay eggs. Thinking of Marsupials, from our neighbour-land New Holland, I made especial inquiry as to an abdominal pouch. The reply was in the negative; and altogether the account pointed to an animal resembling the Otter or Badger, rather than to the Beaver, which some persons have thought it might prove to be.

"I offered this native a handsome remuneration if he would obtain me a specimen, dead or alive, to be taken to Akaroa, and await my arrival; but I saw him no more. Both of the above localities have lately (March, 1849) been travelled over by Mr. Torlesse, one of the Surveyors of the Canterbury Association; but though I especially directed this gentleman's attention to the subject, he was unable to obtain any more satisfactory information as to this unknown (to Europeans) quadruped."—*Letter from Mr. Walter Mantell.*

feathers are long, lanceolate, and of hair-like structure, as in the Emeu, but each shaft bears only a single plume. The beaks are long, slender, and gently curved, with the nasal apertures at the base, as in other birds with a conformation of bill adapted for plunging into water, or soft earth, or mud, in quest of worms or insects; by a strange mistake the nostrils are stated by authors to be at the extremity of the beak. The tongue is short and simple; the hinder limbs are extremely powerful; the tarsometatarsals or shanks are very thick and short, and covered with strong scales. There are four toes; the three anterior ones are robust and armed with

LIGN. 25.—APTERYX MANTELLI: OF NEW ZEALAND.
(Ap. Australis, of *Authors.*)

strong claws, well adapted for scratching up the ground: the hind toe is a thick, sharp, horny spur, used as a weapon of defence.

The wings are quite rudimentary, and are not visible in the ordinary movements of the bird. There are no vestiges of a tail.

These birds are nocturnal and burrowing in their habits, feeding on worms and insects, which they readily detect, their olfactory nerves being highly developed. They inhabit densely wooded districts. The largest and the smallest species are of excessive rarity. Of the former (*Ap. Australis*), two examples only are known; namely, the original, figured and named by Dr. Shaw, and now in the museum of the Earl of Derby; and a specimen sent to me by my son, who captured it in the Middle Island. Of the second species (*Ap. Owenii*), the skins of but two or three individuals have been brought to England.

The third species, (named *Ap. Mantelli* by Mr. Bartlett),[1] though not abundant, and asserted to be rapidly decreasing from the destruction occasioned by the native hunters, and yet more from the ravages of the wild cats, still exists in considerable numbers in the impenetrable thickets of fern in the unfrequented districts of the North Island. Thirty or forty skins are said to have been imported to England last year, and distributed among the museums of Europe and America. In the Zoological Gallery of the British Museum, there are several examples of this bird; and one specimen of the smallest species, which was obtained by Mr. Walter Mantell in the Middle Island.[2] Many fossil bones of the existing species of Apteryx were discovered by my son at Waingongoro.[3]

These observations on the living representatives of the Struthionidæ of New Zealand, will prepare us for the examination of the fossil remains of the extinct giants of their class, contained in the cases in *Room II.*

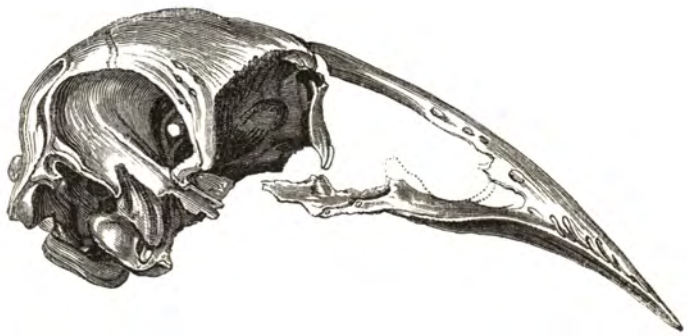
DINORNIS.—*Wall-Case B.—Table-Case* 16. *Lign.* 26, 27.—The name *Moa* is applied indiscriminately by the New Zealanders to all the bones of a large size, though belonging to birds of very different stature and configuration. The scientific term Dinornis (indicating the prodigious gigantic

[1] *Apteryx Mantelli.*—"Mr. Bartlett[a] exhibited a series of stuffed specimens of the genus Apteryx, including the original bird figured by Dr. Shaw, which was lent by the Earl of Derby for this purpose. The result of Mr. Bartlett's investigation goes to prove that the Apteryx in the possession of Lord Derby was unique until the arrival of the specimen exhibited to the Society, and which was obtained by Mr. Walter Mantell in Dusky Bay, and is now in his father's collection. The species which is commonly seen in museums, and has hitherto been confounded with the original *Apteryx Australis* of Dr. Shaw, is in reality distinct, and consequently without a specific designation; Mr. Bartlett, after entering fully into the consideration of the distinctive characters of this species, proposed to name it *Apteryx Mantelli*, in honour of the young naturalist whose researches had enabled the error to be detected."—*Proceedings of the Zoological Society of London, December* 10, 1850.

[2] On the structure of the Apteryx, see Professor Owen's Memoirs in the "Zoological Transactions."

[3] *Apteryx Owenii* and *Ap. Mantelli*, are figured and described by Mr. Gould in his splendid work on the "Birds of Australia;" the latter species under the name of *A. Australis.*

[a] Mr. Bartlett is the eminent taxidermist of No. 23, Great College Street, Camden Town; to whom I entrusted the skins of Notornis, Apteryx, &c. to be stuffed and mounted.



LIGN. 26. SIDE VIEW OF THE CRANIUM.

LIGN. 27. BACK VIEW OF THE CRANIUM.

a. a. Basi-occipitals.
b. b. Par-occipitals.

SKULL OF THE MOA OR DINORNIS: DISCOVERED BY MR. WALTER MANTELL, IN THE MENACCANITE-SAND DEPOSIT, AT WAINGONGORO, IN THE NORTH ISLAND OF NEW ZEALAND. ($\frac{1}{2}$ *nat. size.*)

proportions of the largest species), is now restricted to the most remarkable ornithic type hitherto observed either in a recent or fossil state, and of which there is in the case before us the only cranium and upper mandible that has been discovered.

As the typical crania and many of the bones in this collection are figured and minutely described in Vol. III. of the Zoological Transactions, I would refer the scientific observer to the original memoirs, and confine myself to a concise commentary on the anatomical characters of a few of the principal specimens.[1]

Of the Dinornis there is a nearly perfect cranium, with the upper mandible and portions of two other skulls, in Table-Case 16. This specimen is represented in profile (half the natural size in linear dimensions) in *Lign.* 26 : and the occipital region or hind part of the cranium in *Lign.* 27.

Cranium of Dinornis.—The cranium of the Dinornis, especially in the temporal and occipital regions, is wholly unlike any hitherto observed in the class of Birds, and approaches that of Reptiles. It is characterized by the nearly vertical occipital plane, the elevated form and position of the foramen magnum, the great development below the occipital condyle, and the strong ridges which border the basi-occipitals, and indicate an extraordinary power in the muscles that moved the head. (See *Lign.* 27.) The temporal fossæ are very deep, and are strengthened by a prolongation of the mastoid process, which is united to the frontal, and forms what may be termed a lateral zygomatic arch. The tympanic bone has two distinct cusps for articulation with the double condyle of the os quadratum.

In no bird is the extent of surface for the attachment of muscles at the back of the head so great, or so strongly marked by ridges and depressions, as in the Dinornis. The extension of the occipital surface in breadth by the expansion of the paroccipitals, (*Lign.* 27, *b. b.*) and downwards by the thick wedge-shaped development and abrupt descent of the basi-occipital sphenoidal area (*Lign.* 27, *a. a.*), and by its lateral backwardly produced ridges, is altogether peculiar. The nearest approach to this structure is observable in the large

[1] See Appendix C. *Memoirs on the Dinornis, by Professor Owen.*

Bustard (*Otis tarda*), in the ridges that connect the sides of the basisphenoids with the paroccipital processes.

The form of the foramen magnum is that of a vertical ellipse with straight sides divided by a small tubercle sent off from the ex-occipitals. (*Lign.* 27.) The occipital condyle is a hemispherical tubercle supported on a short pedicle, and is situated in the *centre* of the hinder surface of the skull, the foramen magnum occupying the upper half; these are characters hitherto unknown in the air-breathing vertebrata, and approach those observable in the crania of crocodilian reptiles.

The upper mandible is broad, depressed, and sub-elongate, gently curved downwards, and altogether of a very peculiar configuration; it has been aptly compared to a cooper's adze, or pickaxe. (See *Lign.* 26.) It must have been well adapted for grubbing up roots and tubers; and there is proof in the indications of strong muscles attached to the occipital region, and to the large spinous processes of the cervical vertebræ, that it was a very efficient instrument, and capable of being used with great effect.

The lower mandible is not known; but there is in Table-Case 16, the articular part of a very large lower jaw, that probably belongs to the Dinornis.

From the form and structure of these characteristic parts of the skull and upper mandible, Professor Owen observes that it is manifest the Dinornis cannot be assigned to any known family of birds; and in referring the genus to the Struthionidæ little more is implied than a feeble development of the wings, and large and powerful hinder limbs for progression on dry land: and although some of the anatomical characters above specified exhibit an analogy with those observable in the Bustard, yet the Dinornis is entirely separated from the *Otidæ* by such striking peculiarities of organization, as to show that this genus of the extinct colossal birds of New Zealand, must be regarded as constituting a distinct family of the order *Grallæ*, or Stilt-birds.[1]

Femur, tibia and fibula: in *Case* 15.—To the genus *Dinornis* many of the vertebræ, ribs, bones of the pelvis and hinder extremities, and portions of sterni in Wall-Cases *B* & *C*, and in the Table-Cases 15, 16, and 17, belong. In Table-Case 15, there

[1] Memoir on the Dinornis.

are a femur, tibia, and fibula, and some cervical vertebræ of the same bird, dug up by my son from the menaccanite bed at the base of the inland cliff at Te Rangatapu; though belonging to a young individual, as is shown by the still incomplete union of the proximal epiphysis of the tibia, they are of gigantic proportions. The femur is fourteen inches long, and nine inches in circumference; the tibia, thirty inches in length, six inches round the shaft, and fourteen inches in circumference at the distal end. The entire skeleton of this bird was exposed on removing the soil; the skull and vertebræ of the neck lying extended, and the spinal column, pelvis, and bones of the hind limbs disposed in their natural relative position; but, owing to the sudden inroad of the natives, a few bones only could be rescued from destruction, and in the confusion that ensued, the identification of the bones of the same individual could not with certainty be determined. The femur, tibia and fibula, however, unquestionably belonged to the same bird.

As a guide to the scientific observer, or the student in palæontology, I will point out a few of the most striking peculiarities of the respective parts of the skeleton contained in this collection; but without reference to specific distinctions. It will be sufficient, for example, in reference to the tarso-metatarsal bone, to state that in the genus Dinornis it has three trochlear articulations; while in that of Palapteryx there is a posterior depression for the articulation with the metatarsal of the hind toe; the birds of this genus being tetradactyle, or four-toed, like the Apteryx.

Spinal Column.—Table-Case 17.—The bones composing the spinal column are characterized by their massive proportions, the remarkably thick quadrate spinous processes, especially of the cervical vertebræ, and the small size of the neural canal, indicating a very slender medullary chord. "We may associate with such a condition of the spinal marrow," Professor Owen remarks, "less delicate perception, and less energetic muscular action; thus the characters of the vertebræ confirm the original induction from the texture of the femur, that the Dinornis was a more sluggish bird than the Ostrich."[1]

[1] Consult the commentary on the anatomical characters of the Dinornis, &c. in "Zool. Trans." vol. iii. p. 307, and p. 345.

Sternum.—Portions of several large sternal bones have been obtained. The most perfect example is that figured in Zool. Trans. Vol. iv. Pl. IV. It is of a shield-like form, entirely destitute of a keel, and very slightly convex : it is remarkable for its breadth ; the anterior border from one costal angle to the other is seven inches ; it has a broad median process, and two very long diverging lateral ones. As these characters resemble those of the Apteryx, this sternum is referred to Palapteryx rather than to Dinornis.[1]

Pelvis.—There are in the wall-cases portions of pelves of great size, and which in all probability are referable to the most colossal species of Dinornis or Palapteryx. In respect to this part of the skeleton the extinct birds approach nearer to the tridactyle *Grallæ* than to the living *Struthionidæ.*

In the table-cases there are several delicate pelves of birds of small size, belonging to several genera; they are extremely fragile, and were broken to pieces during their long transport, and have been repaired with much trouble. Some of them belong to the genus Apteryx ; apparently the existing species : others to the bustard-like bird, the Aptornis. There are many specimens of the coalesced *pubis* and *ischium* of different kinds of birds.

Femur or thigh-bone.—Table-Case 15.—The femur of the Dinornis is remarkable for its great strength. The trochanter is very broad, thick, and elevated ; the distal extremity is of great size, and the rotular cavity very broad. The shaft is rounded, and the muscular ridges and tuberosities are more strongly developed than in any other birds. There is no aperture for the admission of air into the interior of the shaft of the bone ; and both the weight and cancellous structure prove the accuracy of Prof. Owen's original statement in his description of Mr. Rule's fragment of the shaft, that the Dinornis at all ages retained the medullary contents of the cavities of the femur, as in the Apteryx ; the only other example of a terrestrial bird in which the air is not admitted into any of the bones of the extremities.

The absence of the pneumatic foramen and canal, the great thickness of the dense osseous wall of the medullary cavity of the shaft, the great size of the distal end of the bone, and the

[1] See "Zool. Trans." vol. iv. p. 17.

breadth of the rotular cavity, are the chief generic characters of the femur of the Dinornis.[1] The largest femur is sixteen inches long, and the shaft seven inches and a half in circumference.

Tibia and Fibula.—Table-Case 15.—The Tibia, even in the species in which it is of great length, is relatively thicker and stronger than in the Ostrich or Cassowary. It is distinguished from the corresponding bone in the Struthionidæ by an oblique bony process that extends across above the distal trochlea, on the anterior and inner side of the bone, and forms a canal for the extensor tendon, as in the Bustard. The longest specimen of a tibia is nearly three feet in length, and the circumference of the middle of the shaft is six inches and a half. The tibia is strongly marked by a ridge for articulation with the *fibula*, which is a long and very slender bone extending two-thirds down the shaft of the leg-bone, and entirely free. My son collected several very large fibula belonging to Dinornis and Palapteryx; and many that are referable to other and much smaller birds. It is remarkable that such delicate fossil bones (as those in the table-cases) should have arrived from the Antipodes in so perfect a state.

Tarso-metatarsals.—Table-Cases 15, 16, 17.—The tarso-metatarsal (shank-bone) is so named because it is formed by the coalescence of the tarsus and the three primary metatarsals into a single bone, which at the distal end is divided into three trochlear articulations for the corresponding number of toes. In the Dinornis this bone is remarkably strong and broad, and of great width at the distal or trochlear extremity. The proximal end has two concavities, the inner one the deepest, for articulation with the tibia. There are no indications of a posterior toe: the Dinornis being a tridactyle, or three-toed bird.

In the unique specimens of the entire series of bones of both feet with the two metatarsals of the same individual of *Dinornis robustus*, collected by my son at Waikouaiti, there is not the slightest trace of an articulating surface for a hind toe.

The ossification of the metatarsals in the Dinornis appears not to have been perfected till a late period, as in the existing

[1] See "Zool. Trans." vol. iii. p. 248.

struthious birds; for in the specimens alluded to, the division of the original three metatarsals is strongly marked, and one of the bones has, unfortunately, cracked by drying, along the line of separation of the primitive ossicles; and yet these bones appear to have belonged to a mature individual.

The longest tarso-metatarsal bones I have seen are eighteen inches and a half in length, the circumference of the shaft being five inches and a half.[1]

Phalangeal Bones.—The bones of the feet bear a closer resemblance to those of the largest species of Apteryx, *Ap. Australis*, than to any of the other existing struthious birds. The phalanges present the ordinary numerical progressive increase, viz. the inner toe is composed of three bones, the middle of four, and the outer of five. The proximal articular surface of the first phalangeal of the middle toe is symmetrically divided by a slight ridge, as in the Cassowary; but in the inner and outer toes the corresponding bone has the proximal end deeply notched, and the inner half greatly produced to embrace the corresponding trochlear surface of the metatarsal.[2]

The ungueal or claw-bones are large and strong, of a subtrihedral form, and gently arched.

In his last visit to Waikouaiti, my son dug up the *entire series* of phalangeals with the corresponding metatarsal of a smaller species of Dinornis; but whether referable to *D. dromioides* or *D. rheides*, or to a distinct species, is uncertain, for the *metatarsal* corresponds with that assigned to the former in Zool. Trans. vol. iv. Plate III. fig. 1, while the series of *phalangeals* are unquestionably of the same species as those figured in Pl. II., and ascribed to *D. dromioides*.[3] In the reconstruction of the foot of the *Dinornis robustus*, my son's specimens have afforded a certain guide.

Several phalangeals were discovered, in which the trochlear articulation of the proximal bone of the middle toe is as unequally divided as in the Ostrich; a character which seems to indicate that a didactyle, or two-toed wingless bird, may have

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[1] These specimens are figured as the frontispiece of the "Pictorial Atlas of Organic Remains."

[2] See figs. 1 & 3 of the same plate.

[3] As the restoration of these parts is based on detached specimens, it is probable the metatarsal does not belong to the series of phalanges with which it is associated.

inhabited New Zealand contemporaneously with the tridactyle Dinornis, and tetradactyle Palapteryx, Aptornis, and Apteryx.

Foot of Dinornis.—The structure of the locomotive organs of one of the largest of the extinct ostrich-like birds is demonstrated by the entire series of bones of both feet of the same individual discovered at Waikouaiti : the dimensions of the several elements are given in the Appendix.[1] Allowing the usual proportion of the soft parts and integuments, the length of the foot in the living bird may be estimated at about sixteen inches, and its breadth at eighteen inches.

According to the relative proportions of the bones composing the hinder extremities of the gigantic species of Dinornis, the height of the bird to which these feet belonged was probably nine and a half or ten feet.

From the great width and solidity of the metatarsals, and the form and corresponding size and strength of the phalangeals and ungueals, it is certain that the feet of the Dinornis must have constituted powerful instruments for scratching, digging, and uprooting subterrestrial vegetable substances, which, from the structure of the crania and beaks, have with much probability been supposed to have constituted the principal sustenance of the original.

Bones of the thigh, leg, and feet, of larger proportions than those above described, are in the Wall-case *C*, and in my own collection. Some of these indicate birds of eleven or even twelve feet high; dimensions exceeding by one-third the stature of the tallest Ostrich : while in other species, as *Dinornis struthioides*, *D. dromioides*, *D. curtus*, and *D. didiformis*, the stature is respectively seven, five, and four feet.

Palapteryx.—*Wall-Case C.; Table-Case* 16. *Lign.* 28, 29. —The other generic type, which comprises some of the largest species of the extinct birds, has been named *Palapteryx;* but it is not, as the term would seem to imply, so nearly related to the existing wingless bird of New Zealand, the Apteryx, as to the Dromaius or Emeu.

Of this genus there is a nearly entire cranium, with the upper and lower mandibles, and several imperfect skulls and beaks,

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[1] Appendix D. Dimensions of the bones of the foot of *Dinornis robustus*. See also "Quarterly Journal of the Geological Society," vol. vi. p. 338.

in Table-case 16, from Waingongoro ; and I have lately received from the same locality other examples.

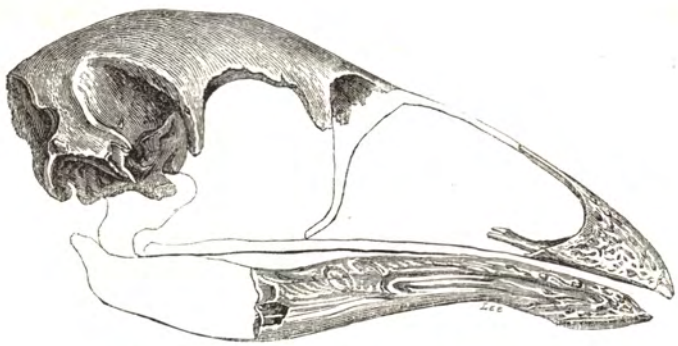
Cranium of Palapteryx.—The cranium (*Lign.* 28) bears a general resemblance to that of the Emeu, but is broader in proportion to its height, especially in the occipital and inter-orbital regions. It is remarkably depressed, of a subquadrate form, with two lateral emarginations for the temporal fossæ ; and both in size and shape corresponds more with the skull of the Dodo than with that of any living struthious bird. It partakes of the general osteological modifications observable in that of Dinornis, as previously pointed out, but differs in the lesser expansion of the *basi-occipitals* (*Lign.* 29, *a. a.*), and *par-occipitals* (*Lign.* 29, *b. b.*), and the greater development of the *mastoid processes* (*Lign.* 29, *c. c.*) ; and in having a large oblong depression beneath the mastoid for the single superior condyle of the tympanic bone.

The *foramen magnum* is subcircular, its plane vertical, and the single occipital condyle projects backwards on a short pedicle, beyond the upper margin of the foramen. The skull of no existing bird has this peculiarity, which resembles the cranial character of some of the chelonians or turtles. The occipital region is very wide and low, and slopes forwards as it rises to join the upper surface of the skull, which is almost flat. (See *Lign.* 29.)

The upper mandible resembles that of the Emeu, but the nasal process is shorter and broader than in that bird. The anterior part (*premaxillary*) is more obtuse than in the Emeu, and its palatal surface has a distinct perforated alveolar border, which is grooved along its outer part. The lower jaw has the symphysis concave above from side to side, instead of flat as in existing struthious birds, and the outer part of the alveolar border is convex and the inner furrowed, thus presenting a surface adapted to the corresponding palatal aspect of the upper mandible.

The *ethmoid* cavities, or upper nostrils, are very large, as in the Apteryx ; a peculiarity denoting a great development of the organs of smell.

The skull with these cranial characters is that described in Professor Owen's second memoir, as the type of his genus *Dinornis*, and from which the outline of the restored head of the original was designed ; but on the discovery of the cranium



LIGN. 28. SIDE VIEW OF THE CRANIUM.

LIGN. 29. BACK VIEW OF THE CRANIUM.

a. a. Basi-occipitals.
b. b. Par-occipitals.
c. c. Mastoid processes.

SKULL OF PALAPTERYX OF NEW ZEALAND: DISCOVERED BY MR. WALTER MANTELL, IN THE MENACCANITE-SAND DEPOSIT AT WAINGONGORO, IN THE NORTH ISLAND OF NEW ZEALAND.

($\frac{1}{2}$ *nat. size.*)

with the enormously developed occipital region, and adze-like upper mandible delineated in *Lign.* 26, and which deviates so remarkably from all known ornithic forms, the name Dinornis was transferred to this type, and the former cranium was assigned to the new genus named *Palapteryx*.

The bones of the hinder extremities referred to this genus are characterised by their nearer approach to those of the Apteryx, than is preserved by the analogous parts in Dinornis. The tarso-metarsals, which belonged to a colossal tetradactyle, or four-toed bird, as shown by a posterior articular depression for connexion with a hind toe, are ascribed to Palapteryx; only one metatarsal of a fourth toe has been observed among the many hundred specimens of bones of the feet that have been collected. Until other series of bones are found collocated in their natural positions or relations, like those of the pair of feet of *D. robustus* (*ante* p. 116), the ascription of isolated bones to definite species, and the restoration of their several members, however skilful the adaptation, must be received with due caution and regarded only as provisional. In many instances, Prof. Owen's application of the Cuvierian principles of correlation of structure, has, however, been signally successful, and warrants full confidence in his general deductions.

Bones of the wings.—Notwithstanding the great number of bones of the hinder extremities and of other parts of the skeleton that have been sent to England, one fragment only, of the *humerus*, has been detected, that could have belonged to any of the large struthious birds of New Zealand; it is supposed to be referable to a species of Palapteryx, and indicates as rudimentary a condition of the wing as in the living species of Apteryx.

Fossil Egg-shells of the Moa.—*Table-Case* 16.—In the deposit of menaccanite-sand at Waingongoro, so rich in the osseous remains of the extinct birds of New Zealand, Mr. Walter Mantell discovered the only vestiges of eggs hitherto obtained. They are small fragments; the largest specimen is four inches long and two wide, and the chord it describes shows it to be part of an egg very much larger than that of the ostrich. These precious relics are relatively thin, of a pale cream colour, and of three distinct types. In one species the external surface is smooth; in another, the surface approaches

that of the Rhea or Cassowary; the third is marked with delicate interrupted linear grooves. The sculpturing in these two species is distinct from that observable on any of the eggs of existing struthionidæ with which I have been able to compare them.

Fossil Eggs from Madagascar.—As intimately connected with this subject, I am induced to append the following notice of a recent discovery in Madagascar of eggs of enormous magnitude :—

"In a Report to the French *Académie des Sciences*, M. Isidore Geoffroy St. Hilaire described three enormous fossil eggs from Madagascar, and some bones belonging to the same bird. The captain of a merchant vessel trading to Madagascar, one day observed a native using for a domestic purpose a vase which much resembled an egg, and upon examination proved to be one. The native stated that many such were to be found in the interior of the island, and eventually procured the eggs and bones exhibited by M. St. Hilaire. The largest of these eggs is equal in bulk to 135 hens' eggs, and will hold two gallons of water. M. St. Hilaire proposes the name of *Epiornis* for the monster biped of which these marvellous eggs and bones are the first evidence brought under the notice of naturalists."[1]

Aptornis.—(*A. otidiformis*).—*Table-Case* 16. (*Lign.* 30.)—Among the bones collected by Mr. Walter Mantell from the ossiferous deposit at Te Rangatapu, and transmitted to me in 1847, there were femora, a tibia and fibula, and several tarso-metatarsals, of a cursorial bird, to which he directed special attention, because he thought the latter strikingly resembled the corresponding bones of the Dodo. Upon allowing Prof. Owen the use of my son's collection as soon as it arrived, the metatarsals in question were recognised as belonging to a species of Dinornis established in 1843, from a tibia and femur sent over by the Rev. W. Williams, and named *D. otidiformis.*[2]

In the "*Memoir on the Ornithic Remains discovered by Mr. Walter Mantell at Waingongoro,*" (Zool. Trans. vol. iii. p. 345), these specimens are alluded to in the following terms :—

"There are not fewer than 190 phalanges of the toes, refer-

[1] Athenæum, March 22, 1851. [2] Zool. Trans. vol. iii. Pl. xxv. xxvi.

able to five or six species of Dinornis, Palapteryx, and Notornis ; and there are eight tarso-metatarsals with the articular surface for a very strong hind toe, and of a conformation more nearly resembling those of the Dodo than of the Dinornis and Palapteryx, but shorter and thicker in proportion, and appertaining to the same bird as the tibia and femora described in my Memoir of 1843, under the name of *Dinornis otidiformis.*

"The proximal articulation of this remarkable form of tarso-metatarsal exactly fits the distal end of the tibia figured, (vol. iii. pl. xxvi. fig. 5,) and also that of a corresponding fractured tibia in Mr. Mantell's collection ; which also contains the proximal end of another tibia, a fibula, an entire femur, and distal ends of two other femora, of the same species.

"The large surface for the hind toe, the strong calcaneal process forming a complete bony canal for the flexor tendons at the back part of the proximal end of the tarso-metatarsal, the perforation above the interspace between the outer and middle metatarsals for the tendon of the adductor muscle of the fourth toe, and the more posterior position of the condyle for the inner toe, all concur to indicate the generic distinction of the bird to which it belonged, from either Dinornis or Palapteryx ; and I propose to distinguish the new genus by the name of *Aptornis ;* and the present species *A. otidiformis.*" [1]

All the specimens above described are deposited in Table-Case 16 ; I have since received other bones belonging to the same remarkable generic type. The annexed figures of one of the metatarsals in my collection, though on a small scale, will serve to impress the peculiar characters of this bone on the observer's memory.

The length from the intercondyloid prominence to the end of the middle trochlea is four inches ; the transverse diameter of the metatarsal articulation is $1\frac{3}{8}$ inches (*Lign.* 30. 2). The great relative width of this bone, the strength of the proximal and distal ends, the greatly produced calcaneal process, the large and deep excavation for articulation with

[1] Zool. Trans. Vol. iii. p. 347.

the hind toe, (*Lign.* 30. 1,) are characters that remarkably distinguish it from the metatarsals of any other genus that have been found in the bone-beds of New Zealand.

LIGN. 30.—TARSO-METATARSAL BONE OF APTORNIS OTIDIFORMIS; FROM THE BONE DEPOSIT OF WAINGONGORO, NEW ZEALAND.
($\frac{1}{2}$ *nat. size.*)

1. Back view, showing the calcaneal process, and articulating depression for the hind toe.
2. Front view; exhibiting the intercondyloid prominence, *a*.

The length of the femur is $6\frac{1}{4}$ inches; of the tibia $8\frac{1}{4}$ inches. The size of the original bird equalled that of the Great Bustard, (*Otis tarda.*)[1]

There are in the collection a series of vertebræ, and portions of the pelvis, as for example the coalesced pubis and ischium, which are probably referable to this bird; but neither the sternum nor any portion of the cranium has been recognised.

FOSSIL BONES OF NOTORNIS—(*N. Mantelli*).—*Table-Case* 16. *Lign.* 31.—In this case are the *cranium* and *mandibles*, the *sternum*, *humerus*, *femur*, *tibia*, and *tarso-metatarsals* of a bird of the Rail family, collected by Mr. Walter Mantell in 1847,

[1] A fine pair of living Bustards (now very rare in England) may be seen in the Zoological Society's Gardens, Regent's Park.

with the remains of the Dinornis, &c., from the menaccanite sand at Waingongoro, which a recent discovery has unexpectedly invested with peculiar interest and importance.

The fossils in question furnished the data on which Professor Owen established the genus *Notornis* (Southern Bird).[1]

The *cranium* (*Lign.* 31) is $4\frac{1}{2}$ inches long, and $1\frac{1}{2}$ inch wide, and is remarkable for its quadrate form ; the front, back,

LIGN. 31.—CRANIUM AND MANDIBLES OF NOTORNIS MANTELLI: FROM THE BONE BED OF WAINGONGORO. ($\frac{1}{2}$ *nat. size.*)

and sides being nearly equal in breadth. The extent of the temporal fossæ are relatively greater than in any other known bird.

The *mandibles* are sharp, like those of the raven, but more compressed laterally, and closely resemble in shape and structure those of the Purple Coot, or Sultana (*Porphyrio*), except in size. The general form of the skull approaches nearest that of the *Brachypteryx*, or short-winged Rail of New Zealand.[2]

The *sternum* (figured in "Zool. Trans.," Pl. IV. fig. 5 and 6) is remarkably narrow, and its keel is less prominent, even

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[1] These specimens are figured and described in "Zool. Trans." vol. iii. Pl. LVI.; vol. iv. Pl. IV. fig. 20.

[2] *Brachypteryx.*—"Besides a species of true *Porphyrio* (*P. melanotus*) in New Zealand, there exists in that island a peculiar and highly interesting form of the Rallidæ, in which the wings, although not so rudimentary as in the Apteryx, are nevertheless so contracted in their development, as to be useless for the purpose of flight. This bird is the type of the genus Brachypteryx—a genus as characteristic of New Zealand as is the Apteryx itself.—PROF. OWEN in "Zool. Trans." vol. iii. p. 370.

The anatomical characters of the skull of Notornis are given in detail in "Zool. Trans." vol. iii. p. 367.

than in the Brachypteryx. There are no styliform appendages, and the median portion of the bone contracts into an obtuse pointed extremity. The coracoid grooves are very shallow; the costal border has depressions for five sternal ribs. The general form and proportions of this bone are indicative of a bird of the same natural family, but with wings less developed than in Brachypteryx.

From the osteological characters above stated, it may be inferred that the Notornis was a large modified form of the same natural family of the *Grallæ* as the Porphyrio and Brachypteryx; and from the configuration of the sternum, it must have been, like the latter peculiar bird of New Zealand, without the powers of flight.

Discovery of a live Notornis.—(*See Frontispiece.*)—The soundness of the physiological inferences relating to the structure and habits of the presumed extinct genus of brevipennate Rails, whose bones were discovered by Mr. Walter Mantell, with those of the stupendous Moa, in the menaccanite-sands of Waingongoro, has recently been confirmed by very unexpected evidence—a specimen of *Notornis*, captured alive in a remote and unfrequented part of the South Island of New Zealand. The following account of this discovery was laid by the Author before the Zoological Society in November, 1850.

According to the traditions of the Maoris, there formerly existed in the Islands of New Zealand, contemporaneously with the gigantic Moas, several smaller birds of various species; and a kind of *Swamp-hen*, or water-rail, was particularised as having been abundant, and a favourite article of food with their remote ancestors. This bird was believed to be extinct, and to have been exterminated by the wild cats and dogs, which at the present time are a great pest to the colonists, destroying the young poultry and other domestic birds, as well as the indigenous species. It was known to the North Islanders by the name of *Moho*, to the natives of the South by that of *Takahé*; but not an individual had been seen or heard of, since the arrival of the English in the country.

The Rev. Richard Taylor, who has long resided in the Islands, had never seen this bird; but in his little work, "A Leaf from the Natural History of New Zealand," under the head of "*Moho*," there is the following note: "Moho, *Rail*:

colour, black; said to be a wingless bird as large as a fowl, with red beak and legs; it is nearly exterminated by the cats: its cry was *Keo! keo!*" The vagueness and inaccuracy of the description prove it to be derived from report, and not from actual observation. On my son's second visit to the southern part of the Middle Island (as Government Commissioner for the settlement of native claims), he fell in with some sealers, who had been pursuing their avocations along the little frequented islets and gullies of Dusky Bay, on the south-western shores, and from them obtained the skin of a recent specimen of *Notornis Mantelli*.

It appeared, that when frequenting the coasts in search of seals and other game, these men observed on the snow, with which the ground was then thickly covered, the foot-tracks of a large and strange bird, and after following the trail for a considerable distance, they caught sight of the object of their search, which ran with great speed, and for a long while distanced their dogs, but was at length driven up a gully in Resolution Island, and captured alive. It uttered loud screams, and fought and struggled violently: it was kept alive three or four days on board the schooner, and then killed, and the body roasted and eaten by the crew, each partaking of the dainty, which was said to be delicious. The skin, with the skull and bones of the feet and legs, was preserved, and fortunately obtained by my son while in good condition, and thus, perhaps, the last of the race of Mohos was preserved for the naturalists of Europe.

Upon comparing the head of the bird with the fossil crania and mandibles, my son was at once convinced of the specific identity of the recent and fossil specimens; and so delighted was he by the discovery of a living example of one of the supposed extinct contemporaries of the Moa, that he wrote to me and stated that the skull and beaks were alike in both, and that the abbreviated and feeble development of the bones and plumage of the wing were in perfect accordance with the indications afforded by the humerus and sternum found by him at Waingongoro, and now in the British Museum, as pointed out in the Zoological Transactions, vol. iii. To the natives of the pahs or villages my son visited on his homeward route to Wellington, the Notornis was a perfect novelty, and excited great interest. No one

had seen such a bird, but all agreed that it was the traditional Moho or Takahé, which they had believed was utterly extinct.

This beautiful bird is about two feet high, and much resembles in its general form the *Porphyrio melanotus*, but it is larger and stouter, and generically distinct : the characters predicated by Professor Owen from the fossil remains, being clearly marked in this recent example.

The beaks are short and strong, and, as well as the legs, were of a bright scarlet in the living animal. The neck and body are of a dark purple colour, the wings and back being shot with green and gold. The wings are short and rounded, and remarkably feeble both in structure and plumage. The tail is scanty, and white beneath. The specific identity of the recent and fossil Notornis is confirmed by Mr. Gould, who has published a coloured figure, the size of the original, in a supplementary number of his splendid work on the "Birds of Australia."

Thus we have at length obtained a recent example of one of the supposed lost types that were coeval with the gigantic bipeds, whose stupendous proportions, and mighty strength, are celebrated in the songs and traditional tales of the New Zealanders, and whose bones, and even eggs, have been transmitted to Europe, and excited the wonder and delight of the natural philosopher and the multitude.

This discovery is of the highest interest alike to the ornithologist and the palæontologist, for this extraordinary form of Rallidæ was previously only known by its fossil remains, and would, probably, like the *Dodo* of the Mauritius (of which the only vestiges are a head and foot), have soon become wholly traditional.

It is possible that another living Moho may be obtained, but the latest communication from my son forbids the sanguine expectation that such will be the case.

Fossil Parrot—(*Nestor*).—*Table-Case* 16.—The islands of the South Pacific are inhabited by a very remarkable genus of nocturnal Parrots (*Nestor*), of which but two species are known. One of these (*N. hypopolius*), is restricted to New Zealand ; the other (*N. productus*) to Philip Island, a mere speck of dry land in the vast Southern Ocean, being only five miles in extent ; and yet, as the eminent ornithologist

Mr. Gould observes, so exclusively is the latter bird confined to that isolated spot, and so rare, that many persons who have resided in Norfolk Island many years, assured him its occurrence there was totally unknown, although the distance from one island to the other is not more than three or four miles:[1] recent accounts state that this species has now become extinct.

Among the bones discovered by Mr. Walter Mantell at Waingongoro are portions of a skull, and two examples of the bony part of the upper beak of a Parrot, which closely resemble in size and structure those of the genus Nestor.

The beak, by its deep, subcompressed, curved, and pointed form, its seeming solidity, pierced by small subcircular nostrils close to its base, attests the family character of Psittacidæ; whilst the proportional length as compared with the depth, the narrow upper surface, where it suddenly expands above the nostrils to join the cranium, the absence of the notch on the under border, the very narrow elongated triangular palatal surface, with the medium linear notch at its base,—all demonstrate that in this characteristic part of the skull, the New Zealand bird represented by it most resembled the living species of Nestor.[2]

Fossil Apteryx; Albatross; Penguin.—In the last collection received from my son there are fossil bones of two species of Apteryx; those of the largest equal in size the homologous elements in the *Ap. Australis;* the lesser bones accord with the corresponding parts of the skeleton of *Ap. Owenii;* but until more perfect examples of crania and other characteristic bones are obtained, the specific identity of the ancient and existing birds cannot be determined. The fact, however, that the living type of tetradactyle struthious birds, known only in New Zealand, was coeval with the stupendous brevipennate Moa, is highly interesting.

Albatross.—Part of a cranium with the upper mandible, not distinguishable from the beak of the yellow-billed Albatross (*Diamodea chlororhyncus*) of the Pacific Ocean, and portions of other bones, dug up at Waikouaiti, prove that this powerful and rapacious bird of flight inhabited the seas and

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[1] "Birds of Australia."

[2] "Zoological Transactions," vol. iii. p. 371, Pl. LIII., figs. 11, 12, 13.

soared over the land, when the Moa and its kindred were the denizens of New Zealand.

Penguin.—The remote antiquity and contemporaneity with the Moa of another indigenous brevipennate genus are established by the discovery of the humerus, ulna, metatarsals, and other bones of Penguins; the partial union, and distinct separation of the shafts of the three primitive ossicles of the metatarsals, are characters that leave no question as to the generic relations of the birds to which these remains belonged.

Fossil Seals.—A considerable number of vertebræ, ribs, femora, scapulæ, lower jaws with teeth, and fragments of crania, belonging to two species of *Seal.* were found in the ornithic bone-beds of the North and Middle Island; and the mineralized condition of these fossils—those from Waingongoro being filled with menaccanite sand, and those from Waikouaiti with the earthy bituminized materials of the submerged morass,—and their intermixture with the relics of the Moa, &c., leave no doubt of their contemporaneity with the superficial ossiferous deposits. Whether these remains belong to the same species as now frequent the shores of the Islands of the Pacific (*Phoca leptonyx*, and *P. leonina*), I have not had the opportunity of ascertaining.

Lign. 32. Fossil femur of a species of Canis: Moa-bed, Waingongoro. *Posterior view; ⅓ nat. size.*

Fossil Dog.—In the most ancient ossiferous deposits at Waingongoro, and at so considerable a depth as to leave no doubt that the animal to which it belonged coexisted with the colossal species of Moa, my son discovered the *femur of a Dog* (*Lign.* 32); the only vestige of a terrestrial mammalian hitherto observed in these beds.

This bone is in the same condition as those of the birds from that locality, and the cancellæ are filled with menaccanite sand. (This interesting and unique relic should be placed in the same cabinet as the cranium with which it was found associated.)

Burnt bones of Man, Moa, and Dog.—Table-case 16.—The natives directed my son's attention to some mounds covered with herbage and ferns, which they informed him contained bones and ashes, the refuse of feasts held by

their ancestors a long while ago. Upon excavating some of these hillocks, they were found to be made up of ashes and calcined bones of men, dogs, and large moas, indiscriminately mingled.

In Case 15, there are fragments of a human clavicle, radius, and some phalangeal bones; lower jaw, teeth, and other bones of dogs; and some pieces of moa-bones. These relics, which have manifestly been subjected to the action of fire, contained no traces whatever of the earthy powder or ferruginous impregnation, so constant in the fossil bones from the fluviatile deposits; nor of the menaccanite with which all the bones from the sand-beds are more or less permeated.

My son, in proof that the birds' remains as well as those of men and dogs, had been exposed to great heat whilst recent, sent me portions of egg-shells charred and bent inwards.

The Rev. J. Taylor mentions having opened similar heaps of bones and ashes in the valley of the Wanganui, and he describes their appearance "as though the flesh of the birds had been eaten, and the bones thrown indiscriminately together." If such was the origin of these heaps, and they are to be regarded as the rejectamenta of the feasts of the Aborigines, cannibalism must have prevailed among the New Zealanders at a very remote period, and ere the gigantic species of Moas were extinct. The practice was doubtless then, as in modern times, connected with superstitious rites, and did not originate from the want of animal food, as some authors have suggested in extenuation of the horrid practice by so intelligent a race as the Maoris.

Retrospective Summary.—From the facts which have been brought under our consideration in the course of this examination of the fossil remains of Birds from our Antipodean Colony, contained in the British Museum, we are led to conclude that at a period geologically recent, but of immense antiquity in relation to the human inhabitants of those islands, New Zealand was densely peopled by tribes of colossal brevipennate birds, belonging to species and genera that have long since become extinct. I believe that ages ere the advent of the Maori tribes, the Moa and its kindred were the chief inhabitants of the country; and that from the period when those islands were taken possession of by

Man, the race gradually diminished, and the colossal types were finally annihilated by human agency.

That some of the gigantic species of Dinornis were contemporary with the Maoris, there can now be no reasonable doubt. Apart from native traditions, and songs and tales in which allusions are made to the magnitude and flowing plumage of the Moa, the collocation of calcined and roasted bones of these birds, with those of dogs, and of the human species, in the ancient fire-heaps of the Aborigines, and the unequivocal marks of the celt or axe of jade on some of the leg-bones,—the incisions having evidently been made on the bones when recent,—afford incontrovertible proof that the last of the *Moas*, like the last of the *Dodos*, was extirpated by man.

From the great size and strength of the thighs, legs, and feet of the Moa, it is clear that the hinder limbs were powerful locomotive organs; and when we consider the vast swarms of the largest species which at one period must have existed, it seems highly probable that this family of colossal birds, —a family unknown either in a recent or fossil state in any other part of the world,—was not originally confined within the narrow geographical limits of modern New Zealand, but ranged over an extensive continent now submerged, and of which Philip and Norfolk Islands, and Chatham and Auckland Islands, and those of New Zealand, are the culminating points.

But whatever may be the result of future discoveries as to the relative age of the bone-deposits, or the existence or total extinction of any of the colossal species of Moas, or the former geographical distribution of the race over countries now submerged, one most remarkable fact must remain unassailable,—namely, the vast preponderance of the class *Aves*, or Birds, which prevailed, and still prevails in the fauna of New Zealand, to the almost entire exclusion of mammalia and reptiles. Any palæontologist who saw the collections formed by my son alone, must have been astonished at their extent and variety. I may venture to affirm that such an assemblage of the fossil bones of birds was never before seen in Europe; upwards of fifteen hundred specimens, collected from various parts of the country, with scarcely any intermixture of the relics of any other class;

it is a phenomenon as startling as the exclusively reptilian character of the inhabitants of the dry land during the Wealden epoch.

But the existing fauna of New Zealand presents a character as exclusively ornithic and anomalous as the ancient one; for while there are upwards of fifty or sixty genera of birds, there is but *one* species of indigenous mammalian known to naturalists,—a frugivorous Rat. The highest representatives of the warm-blooded air-breathing classes, are the Apteryx and Brachypteryx!

In this respect, therefore, as well as in its flora, in which ferns and other cellulosæ prevail to an extent unknown elsewhere, New Zealand is a most remarkable instance of a centre of creation of peculiar organic types. (See *ante* p. 104.)

An important general conclusion of another kind has been deduced by Professor Owen from the amount of agreement between the fossil genera and species of birds, and the existing forms peculiar to New Zealand. For example, the affinity of the fossil Parrot of Waingongoro to the living nocturnal genus Nestor; of the Notornis (now known recent) with the Brachypteryx; of Palapteryx with Apteryx: and, we may add, of species of Apteryx, Albatross, and Penguin, apparently identical with living species.

The Dinornis, if it have no near ally in any known existing bird of New Zealand, appears to have but little affinity to any of the struthious, or other types, in the rest of the world.

The same general accordance in the existing and recently extinct forms of the warm-blooded vertebrata is exemplified in the newest tertiary deposits of Europe and Asia, by the remains of Elephants, Rhinoceroses, Hyænas, &c., and by the absence of those families, and the occurrence of gigantic Sloths, Anteaters, Armadillos, &c. in the pleistocene beds of South America; and has recently been yet more strikingly elucidated by the discovery of fossil gigantic Kangaroos, Wombats, and Daysures, in the bone-caves and freshwater deposits of Australia.[1]

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[1] Dr. Andrew Smith informs me that he has just received notice of the discovery of fossil bones of a marsupial animal related to the Kangaroo, exceeding five times in magnitude those of any living species.

One fact is especially remarkable, and must have excited the surprise of the thoughtful observer,—the contrast presented by the vast accumulations of fossil bones of birds in the swamps, morasses, and pleistocene beds of New Zealand, with the excessive rarity of ornithic remains, not only in the formations of the secondary and ancient tertiary epochs, but also in the most recent alluvial deposits of every other country in the world.

Sir Charles Lyell has commented on the probable causes of the scarcity of relics of so numerous and important a class of vertebrated animals in a fossil state, and suggested, in explanation of the phenomenon, the peculiar organization of birds; their powers of flight necessarily rendering them less liable to be imbedded in the deltas of rivers, or in the bed of the ocean, than quadrupeds; whilst the relatively small specific gravity of their bodies, owing to the tubular structure of the bones, and the lightness of their feathery dermal integuments, occasions the carcases of such as die or fall into the water, to float on the surface till they are devoured or decomposed.

But this argument is scarcely applicable to the colossal brevipennate tribes possessing massive and solid skeletons, as the Dinornis and other extinct Struthionidæ, of whose bones the ossiferous deposits of New Zealand in a great measure consist. The anomaly is probably attributable to a very different cause, namely, the peculiar character both of the ancient and modern faunas of that country, in the entire absence of terrestrial mammalia. The stupendous Moas of the earlier ages of those Islands had no indigenous enemies or devourers, save the carnivorous tribes of their own class.

In the fluviatile, littoral, and marine deposits, now in progress in New Zealand, the skeletons of birds are not likely to be imbedded and preserved more frequently than in the secondary, tertiary, and alluvial strata, of other parts of the world. No such accumulations of ornithic remains as the bone-beds of Waingongoro or Waikouaiti can possibly be formed under existing circumstances; for since the advent of Europeans, a new element of destruction has been introduced into the Islands of the South Pacific; and the apterous birds, and those possessing but feeble powers of flight, and the

young and the disabled of other families, whether volant or cursorial, now become the easy prey of the cats, dogs, and rats, which accompany the Anglo-Saxon races wherever they fix their habitations.

The most rare and interesting indigenous species are at the present moment rapidly diminishing, and must, ere long, be exterminated by the carnivorous predatory mammalia, which have, unfortunately, been added to the fauna of the Antipodes within the last half century ; and the wild cats, (the progeny of the European domestic species) are so numerous and destructive, that it is vain to hope the Notornis (if any of the genus still exists), or the rarer kinds of Apteryx, will long escape the fate of the Dodo and its kindred ; their final extinction cannot be very remote. Possibly, ere many years have passed away, the only known recent example of the NOTORNIS, the individual which forms the subject of the frontispiece of these unpretending pages, will be the sole relic of its race, save the fossil bones preserved in the ancient deposits of its country, and become as precious in the estimation of the palæontologist and ornithologist, as the head and foot of the frugivorous pigeon of the Mauritius.[1]

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[1] See Messrs. Strickland and Melville's splendid and charming work, "*The Dodo and its kindred,*" 1 vol. 4to ; and "Wonders of Geology," p. 130.

CHAPTER III.

PART I.

PLAN OF ROOM III.—SYNOPSIS OF CONTENTS OF ROOM III.—FOSSIL REPTILES — SWANAGE CROCODILE—MEGALOSAURUS—ŒNINGEN SALAMANDER — CHELONIAN REPTILES—GEOSAURUS—PTERODACTYLES—CROCODILIAN REPTILES —MOSASAURUS—HYLÆOSAURUS — IGUANODON — REGNOSAURUS — PELOROSAURUS—POLYPTYCHODON—PLESIOSAURUS—FOSSIL MAMMALIA OF AUVERGNE—MINERALS—MAIDSTONE IGUANODON.

THE Room we have next to survey is more inconveniently crowded even than the apartments we have passed through: the floor being occupied by twenty-six Table-cabinets, so that the objects in the Wall-cases cannot be seen to advantage; and as is the case in the other rooms of this Gallery, there are neither seats nor tables for the convenience of the visitor desirous of noting the objects of interest that may particularly engage his attention.

The collection in this Room, though offering but few attractions to the uninstructed eye, contains many objects of excessive rarity and great interest; and a full description of its varied contents would extend through several volumes. To economise space, the specimens are deposited so as to leave no part of the cases unoccupied; and arrangement is consequently in some measure sacrificed to convenience.

In the subjoined synoptical notice, the principal objects are enumerated in the order in which they are placed in the cabinets; and in the detailed description that follows, I have classified them under a few general heads, for the convenience of the student, without strict regard either to zoological or geological arrangement.

The Wall-cases *A*, *B*, *C*, *D*, *E*, *F*, [1, 2, 3, 4, 5, 6,] on the south side, or left hand, of the Room, contain the remains of

Turtles, Batrachians, Crocodilians, and Saurians, and some splendid specimens of Plesiosauri; these fossils are, for the most part, from the tertiary and secondary formations of England.

This department of Palæontology is of surpassing interest in a physiological point of view, for it reveals to us colossal forms of the class Reptilia, presenting anomalous and most unexpected modifications of structure, belonging to species and genera which inhabited the lands and waters through countless ages, and have long since been obliterated from the face of the earth. Of the remains of many of these remarkable types of cold-blooded vertebrata, the collection in the British Museum contains most valuable and instructive examples.

ROOM III.

(*85 feet long.*)

Synopsis of Contents.

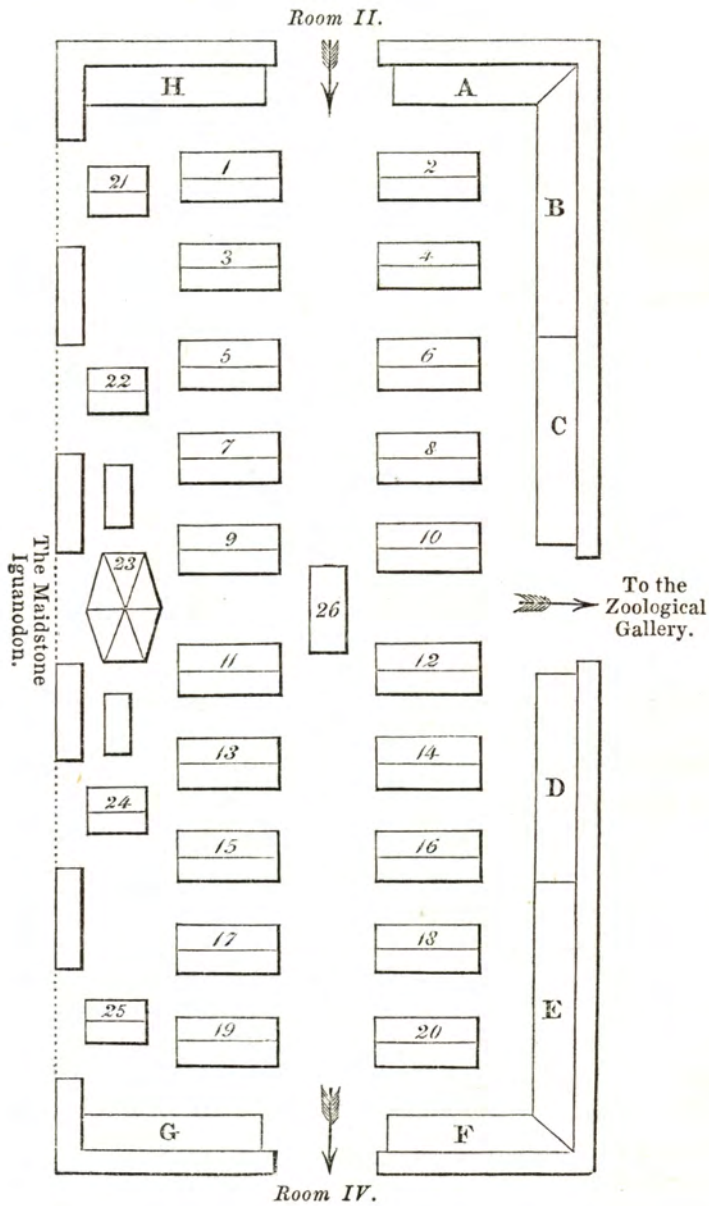
ORGANIC REMAINS.

Wall-cases—*A.* [1.]—*Swanage Crocodile.* (*Goniopholis crassidens.*)—Affixed to the wall are two slabs of fresh-water limestone, being the corresponding parts of the same block of stone, exposing a considerable number of the detached parts of the skeleton of a reptile allied to the Crocodile. This is a most interesting specimen from the Wealden strata at Swanage. Detached bones and dermal plates of the same species from the strata of Tilgate Forest are placed on the shelves below. On the lowest shelf is the cast of a portion of the lower jaw with teeth of the *Megalosaurus Bucklandi*, from the lower Oolite of Stonesfield; the original is in the museum at Oxford.

In the angle of the case (marked *Batrachians*) on the upper shelf, is the celebrated Œningen Salamander, (*Cryptobranchus diluvii testis,*) the subject of Scheuchzer's treatise, "*Homo Diluvii Testis et Theoscopos.*"

On the middle shelves there are many fine examples of

PLAN OF ROOM III.



fossil Chelonians, or Turtles and Tortoises, from the Tertiary deposits at Sheppey, Harwich, &c.; and some interesting detached bones and plates of Turtles from the Wealden of Tilgate Forest, especially of *Tretosternum Bakewelli*, (formerly in the Author's collection.).

Below there are two specimens of a small Crocodilian reptile—the *Geosaurus*, from Solenhofen.

On the left of the above are casts of three species of *Pterodactyles*, or Flying Reptiles, from Solenhofen, viz.—*P. longirostris*, *P. brevirostris*, *P. Munsteri*.

In a small frame is the unique specimen of Pterodactyle, (*P. macronyx*) from the Lias of Lyme Regis; discovered by Miss Mary Anning, and described by Dr. Buckland in "*Geolog. Trans.*" Vol. III. Pl. XXVII. p. 220.

B. [2.]—On the upper shelf are a beautiful head, with part of the vertebral column of *Macrospondylus*, and below a fine cranium of *Crocodilus toliapicus* from the Isle of Sheppey; and a portion of skull, with the jaws and teeth perfect, of a large *Teleosaurus*.

To the right of the *Teleosaurus* is the cranium of *Crocodilus Spenceri*, from the Isle of Sheppey, (figured in Dr. Buckland's "Bridgewater Treatise," Pl. XXV.)

On the shelf below, (immediately above the *Hylæosaurus*,) is a very fine example of *Teleosaurus priscus*, or *Aelodon*, from Monheim. On the *right* of the *Hylæosaurus* are specimens of *Teleosaurus Chapmanni*, and remains of other extinct crocodilian reptiles.

Mosasaurus or Fossil Reptile of Maestricht.—In the lower division of Case *B*, near the angle, is a model of the celebrated specimen of the *Mosasaurus Hoffmanni*, now in the *Jardin des Plantes*. (Presented to the Author by Baron Cuvier.) Above it are two fine portions of the jaws with teeth, of the same species of gigantic reptile, presented in 1784 by Dr. Peter Camper. On the frame of the *Geosaurus* are some detached vertebræ of *Mosasaurus* from Maestricht; and a small slab of chalk in which are imbedded two caudal vertebræ and a detached dorsal vertebra of a species of *Mosasaurus*, (*M. stenodon*,) from the chalk near Lewes. (Figured in "Fossils of the South Downs." 1822.)

Hylæosaurus.—In the lowest department in the centre of Case *B*, is the first discovered specimen of *Hylæosaurus*,

(figured in the "Geology of the South-East of England," Pl. V.); above it is a remarkably interesting portion of the vertebral column, with many dermal bones of another *Hylæosaurus*, (figured in "Phil. Trans." for 1849, Pl. XXXII.).

By the side of the first specimen, to the left of the spectator, are a very large *scapula*, and other bones; and on the right, the proximal end of the corresponding scapula, and the *humerus*, with many portions of ribs, and a phalangeal bone, belonging to the same individual; from a bed of Wealden Clay, near Bolney, in Tilgate Forest.

On the right hand is a model of a nearly perfect *dorsal dermal spine* of the *Hylæosaurus*, (the original, fourteen inches long, discovered by Mr. Peter Fuller, of Lewes, is in the possession of the Author,) figured in "Phil. Trans." 1850, Pl. XXVII.

C. [3.] *Iguanodon.*—The contents of this Case are chiefly bones and teeth of reptiles of the genus *Iguanodon*, from the strata of Tilgate Forest, in Sussex, discovered and developed by the Author.

Upper Shelf.—On the left a very fine *Coracoid* bone imbedded in Tilgate grit; and a portion of another Coracoid.

A *scapula*, eighteen inches long, of an unknown reptile; (figured and described in "Phil Trans." 1841, Pl. IX. X.).

Portions of a very large *Scapula*, probably of *Pelorosaurus;* (figured in "Fossils of Tilgate Forest," Pl. XVI.).

Fragment of the shaft of a *Femur* twenty-three inches in circumference. (Marked No. 4.) See "Fossils of Tilgate Forest," Pl. XVIII.; this was the first portion of a colossal bone discovered by the Author in the Wealden of Sussex, in 1820.

Two pieces of a *femur, tibia, fibula,* and *two metatarsal bones*, of the same young and comparatively small Iguanodon.

Bone in a block of Tilgate grit; undetermined.

Fragment of a very large *Os pubis*, probably of the Iguanodon.

Near this specimen there is a bone supposed to be part of the *Ischium*, but it is imperfect at the extremities, and the form of the original cannot be ascertained with certainty. There are portions of several other bones on this shelf that cannot be satisfactorily interpreted till more perfect specimens are discovered.

Second Shelf from the Top.—On the left, two small cylindrical bones, possibly of the anterior extremity of a young Iguanodon. *Tibia* and *fibula*, (marked No. 2) of the same individual as the femur on the right hand, (labelled No. 5.) These three specimens give the relative proportions of the thigh and leg of this species of Iguanodon.

A very fine femur (marked No. 3); and the largest and most perfect in the collection, (marked No. 1,) which is forty-four inches long, and twenty-two inches round the shaft; this specimen was dug up from the Weald Clay near Loxwood, in Sussex, and presented to the Author by the late Earl of Egremont.

Sacral vertebræ.—On the trays containing these magnificent thigh bones, there are placed four specimens of sacral vertebræ, which are highly interesting. The right hand vertebræ are a portion of the sacrum of the *Megalosaurus;* the generic relations of the next specimen, (which is figured in "Philos. Trans." for 1841, Pl. IX. fig. 5,) is not ascertained: the single sacral vertebra on the left belongs to the Iguanodon; the fourth specimen is part of the sacrum ascribed, with much probability, to the *Hylæosaurus.* "Brit. Assoc. Report," p. 114.

Narrow Shelf.—Numerous teeth, comprising upper and lower molars of Iguanodon, of various ages, and in different stages of detrition.

Polished transverse sections of the *tibia* of a young Iguanodon.

Portion of the anterior part of the *upper jaw* of the Iguanodon; (figured and described in "Phil. Trans." 1848, Pl. IX.)

Horn, or dermal tubercle, (figured in "Fossils of Tilgate Forest," Pl. XX. fig. 2,) probably of the Iguanodon.

Portion of the lower jaw of a reptile, *Regnosaurus Northamptoni*, (figured and described in "Phil. Trans." 1841, Pl. V. and 1848,) from Tilgate Forest.

Lower Division.—Numerous ribs, vertebræ, and chevron-bones, and bones of the extremities; namely, *metatarsals* or *metacarpals, phalangeals*, and *ungueals.*

A slab of Tilgate grit with *six anterior caudal vertebræ*, and three *chevron-bones* of an Iguanodon; a matchless specimen.

Below this fossil are several ribs, and a portion of a remarkably fine rib, thirty-six inches long.

A perfect *Clavicle*, (figured in "Geology of the South-East of England," Pl. IV.), and portions of others.

There are *chevron bones*, and many detached vertebræ on the shelf to the left of the central specimen; chiefly caudal of the Iguanodon: but there are a few belonging to other genera, as *Megalosaurus*, *Poikilopleuron* (?), *Goniopholis*, &c.

Tympanic bones.—On the right hand is one very large and fine specimen, (figured in "Geology S. E. of England," Pl. XI. fig. 5.).

Humerus.—A model; the original is in the possession of Mr. Fowlestone, of Ryde, Isle of Wight. It afforded the data by which I was enabled to determine the character of this part of the skeleton of the Iguanodon.

In the same compartment there are casts of a metatarsal or metacarpal, and two phalangeal bones of Iguanodon, from the Wealden of Sussex, presented by S. H. Beckles, Esq. of Hastings.

Pelorosaurus.—The four splendid plano-concave vertebræ placed together, with a chevron bone hanging near them, do not belong to the Iguanodon, but are referred, provisionally, to a colossal reptile of the Crocodilian type, named by the Author *Pelorosaurus Conybeari;* (figured and described in "Phil. Trans." 1850, Pl. XXII.) They are the *Cetiosaurus brevis*, of "Brit. Assoc. Report," 1841. Some of the other large vertebræ of this type probably belong to the same genus, and other biconcave vertebræ to the genus *Cetiosaurus.*

There are two imperfect convexo-concave cervical vertebræ, which have been referred to a species of *Streptospondylus*, (see "Brit. Foss. Rept." p. 92), but probably belong to the Iguanodon or Megalosaurus.

Megalosaurus.—There are *femora*, *phalangeal bones*, and many teeth of this Reptile, from the Wealden of Tilgate Forest; and portions, (three anchylosed vertebræ,) of the *sacrum*, from the Oolite of Stonesfield.

There is also the cast of a metatarsal or metacarpal bone of the Megalosaurus, from the original in Dr. Buckland's possession, and which was given me by that eminent palæontologist: it serves to illustrate the homologous bone in the Iguanodon.

Two enormous *coracoids*, a *femur*, and part of a *clavicle* of the *Megalosaurus*, have lately been discovered at Stonesfield, and added to the Museum collection: these are at present in Room II. Wall-case *C*.

In the following cases commences the matchless collection of British Enaliosaurians, or Marine Reptiles, chiefly of the genera *Plesiosaurus*, and *Ichthyosaurus*, from the Lias of Dorsetshire, Somersetshire, and Gloucestershire, collected by Thomas Hawkins, Esq. F. G. S.

D. [4.] A beautiful *Plesiosaurus Hawkinsii*, and a cast of the same.

Plesiosaurus dolichodeirus. (Long-necked—the neck being equal in length to the body and tail united.)—On the top of this case is the original specimen of this species, described by Rev. W. D. Conybeare in 1822. (See "Geol. Trans." *second series*, vol. i. Pl. XVIII.)

E. [5.] On the left, *Plesiosaurus macrocephalus*, presented by the Earl of Enniskillen.

Plesiosaurus rugosus, from the Lias near Belvoir Castle; a nearly entire specimen of this rare species; presented by the Duke of Rutland.

F. [6.] In the upper division, *Plesiosaurus Hawkinsii*. Below are exquisite specimens of the same species, and part of a *Plesiosaurus dolichodeirus*.

Above Case *A*, are remains of large fossil Turtles.

" " *C*. Portions of the skeleton of a gigantic marine reptile (*Polyptychodon*), from the Greensand of Hythe, in Kent, presented by H. B. Mackeson, Esq.

" " *D*. The original specimen of *Plesiosaurus dolichodeirus*.

" " *E*. A specimen of *Plesiosaurus arcuatus*.

G. [7.] Remains of Mammalia, Birds, and Reptiles, from the Eocene lacustrine deposits, near Clermont, in Auvergne. This most valuable collection is not yet arranged; it comprises many species and genera of pachyderms allied to the Anoplotheria; rodents, carnivora, marsupials, ruminants, and saurian and batrachian reptiles. There are several fossil eggshells, either of birds or reptiles.

H. [8.] Bones, teeth, &c. of Ruminants and Pachyderms, from the Diluvium or Drift. (Unarranged.)

MINERALS.

TABLE-CASE 1.—[47.] Carbonates of lime and magnesia. Rhomb-spar; dolomite; brown spar; flexible dolomite, from Pittsfield, Massachusetts, North America.

2. [14.] In this and Cases 15 and 16, are deposited most of the oxides of iron. Magnetic iron ore; crystallized varieties; natural magnets; magnetic ironsand.

3. [46.] Calcite; pisiform limestone, or pea-stone, from the hot springs of Carlsbad, in Bohemia. Tufaceous limestone. *Human skull* incrusted, from the Tiber, at Rome. Tufaceous casts, from the Baths of San Filippo, near Tivoli.[1]

4. [15.] Iron-glance, or specular oxide, from Elba, Stromboli, Vesuvius: red ironstone, and red hematite.

5. [45 *A* and *B*.] Marbles of various kinds. In [45 *A*.] specimens of the *Corinthian lumachella*, or fire-marble: the beautiful play of colours is produced by the fossil laminated shells imbedded.

6. [16.] Hydrous oxide of iron, or brown ironstone. Specimens of argillaceous, or clay ironstone, as the reniform, columnar, and pisiform, or pea-ore.

7. [45.] Prismatic modifications of crystallized calcite, with stalactites and fibrous varieties, from Sweden, Cumberland, &c.

8. [17.] Oxides of copper; red, or ruby copper; black oxide; oxide of bismuth; red oxide of zinc; red and yellow earthy cobalt. Oxide of uranium.

9. [43, 44.] Crystallized varieties of calcite or calc spar; specimens illustrative of double refraction, cleavage, supernumerary joints, colour, &c.; secondary, obtuse, and acute rhombohedrons. Crystallized sandstone of Fontainbleau.

10. [18.] Oxide of lead; native minium. Oxide of tin or tinstone. Metallic tin; some thick tin wires, brought from Soudan, in Africa, by Captain Clapperton.

11. [11.] Various forms of aragonite. A variety of carbonates of lime, containing a small percentage of carbonate of strontia; coralloidal aragonite; varieties of carbonate of lime, or calcite.

12. [19.] Alumina and Aluminates. Corundum; Emery; Indianite. Aluminates of magnesia; the spinel; chrysoberyls, in large crystals, from Brazils and the Urals; and in a

[1] See "Wonders of Geology," vol. i. p. 75.

matrix of quartz and felspar, with garnets from Haddam, in Connecticut.

13. [41.] Carbonates of soda; of barytes, or witherite; barytocalcite; carbonate of strontia.

The remainder of this Case is filled with varieties of aragonite.

14. [20.] Amethystine quartz. Rock crystal in various modifications and colours, from Gibraltar, Bristol, &c.; rock crystal in a wrought state; among these is the celebrated Dr. Dee's show-stone. (See Sir Walter Scott's "Demonology.")

15. [40.] Silicates, with one or more borates. Tourmaline; axinite; rubellite; of the latter a remarkable example, presented by the King of Ava to the late Col. Symes. Indicolite, &c.

16. [21.] Common quartz in great variety; numerous pseudomorphous crystals, derived from modifications of calcareous and fluor spars. Stalagmitic quartz from the hot springs of the Geysers in Iceland, Santa Fiora in Tuscany, and from Luzon, one of the Philippine Islands. Specimens of "lightning tubes," from England and from Africa. Hyalite, Haytorite, aventurino quartz, &c.

17. [39.] Molybdic acid and molybdates. Oxide of chromium and chromates. Boracic acid, or sassoline, from Vulcano; borate of magnesia; datholite, &c.

18. [22.] Varieties of quartz. Prase; hornstone; among the specimens of hornstone is a splendid example of the silicified stem of a palm (*psarolinite*); cat's eye, from Ceylon; chert; flint; groups of stalactitical flint passing into calcedony; flint nodules, containing water; calcedonies.

19. [38.] Silicates containing yttria and protoxide of cerium. Combinations of columbic, or tantalic acid, with protoxides of iron, lime, magnesia, yttria, zirconia, &c. Oxides of antimony. Tungstates. Vanadic acid and vanadates.

20. [23.] Calcedonic substances, cut and polished. Carnelian; plasma; heliotrope; bloodstone; chrysoprase from Kosemütz, in Silesia. Agates; a beautiful agate nodule, from the trap formation of Central Asia, presented by C. Fraser, Esq.

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21. Table containing polished slabs of various marbles.

22. Table with polished slabs of coralline marbles.

23. The MAIDSTONE IGUANODON. (*See "Wonders of Geology,"* Pl. I.)—In the hexagonal case placed on the ground beneath the central north window is a block of Kentish rag, or sandstone, containing a considerable portion of the skeleton of a young Iguanodon; the bones are separated and displaced. Discovered in a quarry of Kentish rag, near Maidstone, Kent, by Mr. Bensted, 1834. This is the most remarkable specimen of the Iguanodon hitherto obtained.

24. Table of Serpentine. Table inlaid with porphyries, &c.

25. This table contains a fine series of bivalve shells (*Conchifera*), one division from the Tertiary strata—chiefly from the *Crag;* the other from the *Inferior Oolite*, and other secondary deposits; arranged and named by Mr. Woodward.

26. In the centre of the room is a table formed of an extremely beautiful stalagmitic marble, from Hartle, Derbyshire.

CHAPTER III.

PART II.

FOSSIL REPTILES.

AGE OF REPTILES—FOSSIL BONES OF REPTILES—FOSSIL TURTLES—PLATEMYS—CHELONIA HARVICENSIS—CHELONIA BREVICEPS—WEALDEN TURTLES—CHELONIA BELLII—EMYDIANS—TRETOSTERNUM BAKEWELLI.

THE AGE OF REPTILES.—The announcement of the illustrious Founder of Palæontology, that there was a period when the lakes and rivers of our planet were peopled by reptiles, and cold-blooded oviparous quadrupeds of appalling magnitude were the principal inhabitants of the dry land,—when the seas swarmed with saurians exclusively adapted for a marine existence, and the regions of the atmosphere were traversed by winged lizards instead of birds, was an enunciation so novel and startling, as to require the prestige of the name of CUVIER to obtain for it any degree of attention or credence, even from those who were sufficiently enlightened to perceive that a universal deluge would not account for the mutations which the surface of the earth and its inhabitants had, in the lapse of innumerable ages, undergone.[1]

Subsequent discoveries have, however, established the truth of this proposition to an extent beyond what even its promulgator could have surmised; and the "*Age of Reptiles*"[2] is now admitted into the category of established facts.

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[1] "Nous remontons donc à un autre âge du monde; à cet âge où la terre n'étoit encore parcourue que par des reptiles à sang froid—où la mer abondoit en ammonites, en bélemnites, en térébratules, en encrinites, et où tous ces genres, aujourd'hui d'une rareté prodigieuse, faisoient le fond de sa population."—*Ossemens Fossiles*, tom. v. p. 10.

[2] "*The Age of Reptiles*," was the title given by the author to a popular summary of the evidence bearing on this question, which was published in the *Edinburgh Philosophical Journal* for 1831. The name, as now generally employed, comprises those geological epochs which are characterized by the predominance of oviparous quadrupeds, viz. from the Trias to the Chalk inclusive.

During the incalculable ages which the deposition of the various systems of sedimentary strata must have comprised, we find no evidence in the fossils hitherto observed, of the existence of Birds and Mammalia as the characteristic types of the faunas of the dry land. On the contrary, throughout the immense accumulations of the spoils of the ancient islands and continents, amidst innumerable relics of reptiles of various orders and genera, portions of six or seven lower jaws, and a few bones, of two genera of extremely small terrestrial quadrupeds, and the bones of a species of wading bird, are the only indications of the presence of the two grand classes, *Mammalia* and *Aves*, which constitute the chief features of the terrestrial zoology of almost all countries.

The earliest indications of air-breathing vertebrata in the ancient secondary formations, are the supposed footprints of a chelonian reptile on the Potsdam limestone (Lower Silurian) of North America,[1] and the bones of small saurian reptiles in the Carboniferous strata; a few vestiges occur in the succeeding group, the *Permian*. In the next epoch, the *Triassic*, colossal Batrachians (*Labyrinthodons*) appear; and on some of the strata of this formation are the footmarks of numerous bipeds, presumed to be those of birds, which have already engaged our attention; but at present the evidence required to establish the hypothesis is incomplete, for no bones of the animals that made those imprints have been discovered.

In the succeeding eras, the Liassic, Oolitic, Wealden, and Cretaceous, swarms of reptiles of numerous genera and species everywhere prevail; reptiles fitted to fly through the air, to roam over the land, to inhabit the lakes, rivers, and seas; and yet not one identical with any existing forms! These beings gradually decline in numbers and species as we approach the close of the Secondary periods, and are immediately succeeded, in the Tertiary epochs, by as great a preponderance of warm-blooded vertebrata—Birds and Mammalia—as exists at the present time, and an equal decadence in the Class of Reptiles. With the Cretaceous Formation the "*Age of Reptiles*" may therefore be said to terminate.

[1] A discovery recently made by Mr. Logan is supposed to establish this fact. Casts of these very equivocal imprints may be seen in the highly instructive and beautifully arranged Museum of Practical Geology, in Jermyn Street, London.

Fossil Bones of Reptiles.—The state of mineralisation of the fossils we have now to examine, differs considerably from that presented by the ornithic relics from New Zealand. The osseous carapaces and plastrons of the turtles, and the bones and teeth of the crocodiles and lizards, are almost without exception heavy, and of various shades of brown or umber, from the permeation of their structures by solutions of carbonates or oxides of iron.

In some instances, bones of a jet black are imbedded in white calciferous grit; the phosphoric acid in the original organism having combined with iron and produced a deep blue or black phosphate of that mineral, and left the surrounding stone uncoloured.

Infiltration of calcareous spar is a mode of fossilisation equally common; and the cancellous structure, and the medullary cavities of the long bones, are very often filled, more or less, with white calc-spar; brilliant pyrites also enters into the composition of these fossils, frosting over with a golden metallic deposit the linings of the cavities and fissures.

The petrifaction of the teeth by mineral matter, produces beautiful examples of the intimate tissues of those organs; the dentine is often stained throughout with a rich sienna tint, and sections viewed under the microscope by transmitted light, reveal the character and distribution of the calcigerous tubes more defined even than in recent specimens.

It is extremely rare that osseous structures are found silicified, or, in other words, petrified by flint; among the many thousands of bones which I have extricated from the rock, or have seen in collections, I know but of a solitary instance, a caudal vertebra of a Mosasaurus, which I obtained from a chalk-pit near Brighton. But notwithstanding the weight and apparent solidity imparted by these modes of mineralisation, the osseous substance is generally rendered extremely brittle, so that the development of the bones from the stone in which they are imbedded, and the removal of the hard ferrugino-calcareous crust investing them, is no easy task, but requires much tact and experience and patience to execute successfully.

The observer, therefore, must not suppose that specimens like the fossil Turtles and Reptiles in the first Cases, or the colossal bones from the Wealden, in Case *B*, or the

splendid skeletons of Plesiosauri spread out on slabs of grey limestone in Cases *D* and *E*, are to be found in the strata in a condition that would admit of their being even recognised as organic remains by the uninstructed eye. On the contrary, mere shapeless masses of rock, with here and there fragments of bone scarcely distinguishable from the surrounding stone, are in general the sole indications of these precious monuments of distant ages, that have been enshrined for an incalculable period, and which require the skill and labour of the practised explorer to develop and render intelligible to the comparative anatomist.

The degree of distortion which the strong and massive bones of the colossal reptiles of the Wealden have in many instances sustained, is truly remarkable. Leg and thigh-bones, and the bodies of vertebræ of enormous size, and which were originally of a sub-cylindrical form, are found twisted, contorted, and pressed almost flat, and yet with but slight indications of fracture. It is clear that the skeletons of the stupendous saurians must have been rendered plastic by long maceration in water before the mud and sand in which they were engulfed had consolidated around them, and ere their tissues were permeated by mineral matter.

The Maidstone Iguanodon, (*Table-Case* 23 of the plan, *ante*, p. 138,) is a striking example of this kind; in the entire series of bones exposed, there is scarcely one that is not more or less altered by compression. The humerus and thigh-bones especially, are completely distorted; the vertebræ pressed almost flat, or squeezed into abnormal shapes; one of the clavicles is twisted and thrown into the most fantastic position; and so great was the transformation the bones had sustained, that although Mr. Bensted had spent weeks in clearing out the most obvious masses of bone, and had marked the relative connexion of the principal pieces into which the specimen had been fractured by the explosion of the rock, it was several months, and with the aid of a mason, before I succeeded in cementing the pieces together, and restoring the fractured parts to their present state; nor could this have been successfully effected, had I not previously obtained perfect specimens of almost all the parts of the skeleton of the Iguanodon, which in this instructive fossil were found associated together for the first time, to guide

my chisel, and enable me to avoid the destruction of concealed portions of bone.[1]

With these prefatory remarks to prepare the uninstructed visitor for the general appearance of the fossilized osseous remains deposited in this apartment, we proceed to examine somewhat in detail, the various relics of petrified reptiles it contains.

Fossil Turtles. — *Wall-Cases A* and *B*. [1, 2.] — The earliest indications of the presence of Reptiles on our planet, are those afforded by the foot-prints of Turtles or Chelonians, apparently of terrestrial species, on the surfaces of the layers of sandstone of the New Red formation, in Dumfriesshire in Scotland, at Storton, near Liverpool, and in several places in Germany.[2] But no osseous remains of Chelonia have hitherto been found in strata antecedent to the Oolite.

The Solenhofen quarries have yielded the bones and carapaces of several species of marine Turtles: and scutes and bones of animals of this family have been found at Stonesfield, and in the Bath and Portland Oolite. In the Jura limestone at Soleure, two large species of Emydians (fresh-water tortoises) have been discovered.

The Wealden formation contains Chelonian remains of fluviatile and marine genera; many specimens have been collected in the Isle of Purbeck; and my own researches in the strata of Tilgate Forest have brought to light several species, and in particular an interesting Chelonian related to the soft-skinned, fresh-water Tortoises (*Trionyces*).

In the Cretaceous formation of England the remains of these reptiles are not frequent. The Greensand of Cambridgeshire and of Kent has yielded marine species; and in the White Chalk a few beautiful examples have been obtained.

On the Continent, fossil turtles have been found in the slate of Glaris; and in the upper Cretaceous strata at Maestricht. At Melsbroeck, near Brussels, very fine specimens of fresh-water (*Emydes*), and marine (*Chelonia*) turtles have been discovered.[3]

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[1] Consult "Medals of Creation, or First Lessons in Geology," for additional remarks on this subject.

[2] See Dr. Buckland's Bridgewater Essay, vol. i. p. 259.

[3] "*Oss. Foss.*" Tome v. pp, 236, 239.

From the Eocene strata of England remains of several genera have been obtained. The Isles of Sheppey and Wight, and the coasts of Hants and Essex, have yielded fossil Chelonians in considerable numbers.

The Eocene Strata of France contain several fresh-water Tortoises, some of which belong to the family of *Emydes*, and others to *Trionyces*.

Testudinata, or Land-Tortoises, are exceedingly rare; no unquestionable remains of this kind are known in the British strata;[1] but the Tertiary formations of India have furnished decided examples; and among the innumerable relics of vertebrata which the indefatigable labours of Dr. Falconer and Major Cautley have brought to light, and skilfully developed, are the remains of Land-Tortoises of prodigious magnitude, to which we have already adverted when pointing out the model of the *Colossochelys Atlas*, at the entrance of Room I. (*ante* p. 11). These remains are associated with the bones of gigantic extinct mammalia, allied to the *Palæotheria* and other pachydermata of the Paris basin; and with those of *Gavials*, and of small Land-Tortoises, of species that still inhabit India.

The fossil remains of Chelonian reptiles generally consist of the detached plates of the carapace and plastron, but considerable portions of the convex shell formed by the expanded and united costal plates, and of the plates of the sternum, are not uncommon. In a few instances, as in the Isle of Wight Eocene Turtles, collected and developed with consummate skill by the Marchioness of Hastings,—and some of the Sewalik Chelonians chiselled out of the rock by Mr. Dew, and placed in Room VI.—the entire carapace or buckler, and sternum or floor, are as perfect as in the recent skeleton. The cranium and bones of the pelvic and pectoral arches, and of the paddles, are often found detached, and occasionally in connexion with the carapace.

CHELONIANS.—*Wall-cases A-B.*—The fossil Turtles in this

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[1] At the head of British Chelonia (*Brit. Rep.* p. 190), *Testudo Duncani* (*Owen*), is placed; but the Report does not contain the description of any Chelonian remains that can be referred to this species. Equivocal imprints on stone are surely insufficient, in the absence of all corroborative evidence, to justify either generic or specific distinctions.

apartment are placed on the shelves in the angle uniting Wall-cases *A* and *B* of the plan (*ante* p. 138). The following diagram will assist the visitor in finding the objects described.

CASE marked CHELONIANS in Room III. :—

Upper Shelf.—Œningen Salamander.

Fossil Turtles from Harwich; Chelonia Harvicensis.

Turtles from the Isle of Sheppey.

Turtles from the Wealden of Tilgate Forest.

Vertebræ of Mosasaurus from Maestricht; and from the Chalk at Lewes.

Pterodactyle from Lyme Regis.	Geosaurus Soemmeringii.	Two small cases with the jaws, teeth, &c. of the Geosaurus.
Models of Pterodactyles.	Two very interesting specimens of the skeleton of this Crocodilian reptile, from Monheim.	

Platemys Bullockii.[1]—*Wall-case A-B.*—One of the most conspicuous of the fossil Turtles in the angle uniting the Cases *A* and *B*, is labelled as above; the specific name indicating its former possessor, the late Mr. Bullock, in whose museum in Piccadilly it was exhibited many years since.

This Turtle was discovered in the Eocene clay of the Isle of Sheppey; the plastron or floor is 16 inches in length and 14 inches in breadth, and is almost flat; the carapace is remarkably low. It belongs to the family of Marsh-Tortoises (*Paludinosa*) which much resembles the true Land-Tortoises (*Testudinidæ.*)

CHELONIA *Harvicensis.*—*Wall-case A-B.*—Two fine specimens, one exhibiting the inner surface or concavity, and the other the convexity of the carapace of a large marine Turtle, are placed in the centre of this compartment; they are from the Eocene argillaceous beds on the Essex coast. As remains of this Turtle were often found on the shore, near Harwich, my friend the late *Mr. Samuel Woodward*,[2] figured and described the species as *C. Harvicensis* in a valuable work, which was the first attempt to tabulate the British fossils; a labour since so ably carried out by

[1] Prof. Owen, in Palæontographical Society's Trans., 1849. Pl. XXI.

[2] The father of Mr. S. P. Woodward of the British Museum, one of the Curators of the Palæontological department.

Mr. Morris ; the frontispiece of that volume represents a fine carapace in the Norwich Museum.[1]

Mr. Woodward states that the buckler or shell of this Chelonian reptile often forms the nuclei of the septaria or cement-stones which occur in the eocene clay of the Norfolk coast ; the one figured was dredged up from the Stour Ridge, which lies four miles out at sea from Harwich Harbour ; it is 22 inches long and 18 wide. Specimens of the convex or outer surface of the carapace are less common than those that expose the interior.

This Turtle was figured and described by Mr. Konig, under the name of *Testudo plana* in the *Icones Sectiles*, fig. 192 ; and Prof. Owen has figured the Museum specimen (which is $13\frac{1}{2}$ inches long, and 10 inches wide), in his "Monograph on the Fossil Reptilia of the London Clay," Pl. XI. and XII., as *Chelone crassicostata* ; a name derived from the great thickness of the ribs which is peculiar to this species ; but it appears to me improper to expunge the specific name of a fossil that has been figured and described by an original observer, with sufficient clearness to enable the species to be identified. In every department of natural history unnecessary changes in nomenclature are most serious impediments to the advancement of scientific knowledge.

CHELONIA *Breviceps*.—("*Pictorial Atlas*," Pl. LXIX. fig. 2, 3.)—A nearly perfect cranium of a marine turtle from the Isle of Sheppey, named *Emys Parkinsonii* by Mr. Gray, and *Chelone breviceps* (short-skull) by Professor Owen, is placed in this Case: it approaches in form the recent *C. mydas*. In Mr. Bowerbank's collection there is a cranium of the same species, attached to the carapace and plastron: it is a small turtle, about seven and a half inches long.[2]

In the late Mr. Dixon's collection (now added to the National Museum) there were several species of eocene turtles, which are figured and described in his work; as, for example, *C. declivis, C. trigoniceps*, &c.; but these interesting fossils are not at present exposed to view.

FOSSIL TURTLES OF THE WEALDEN.—*Wall-case A. B.*—

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[1] "Synoptical Table of British Organic Remains;" by Samuel Woodward: Norwich, 1830.

[2] Figured in "Palæontographical Monograph," 1849, Pl. I. II.

("Fossils of Tilgate Forest," 1827, Pl. VI. and VII.)—Water-worn comminuted bones and costal plates of Chelonian reptiles, are abundant in the Wealden deposits of the Isle of Purbeck, and Isle of Wight, and in the clays and sandstones of the Weald of Sussex. Their occurrence in the Purbeck beds was made known by Mr. Webster; and in the Wealden, by my early gleanings from the strata of Tilgate Forest.

With the increase of collectors, and activity of research, that followed the publication of my works on the Fossils of Sussex, remains of Chelonians of considerable interest were brought to light; but with the exception of a few almost perfect examples of the carapace and plastron from near Swanage, and considerable detached portions of the same parts from the Hastings beds of Sussex, I am not aware that more instructive relics have been discovered than those in the Case before us, which were collected by me nearly thirty years ago.[1]

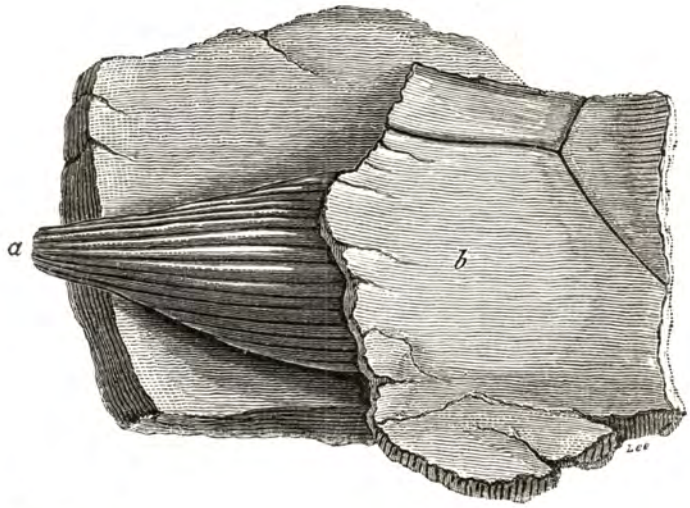
In my "Fossils of Tilgate Forest," (published in 1827,) Pl. VI. and VII.,[2] are figured costal-plates of the carapace, portions of the plastron, and of the scapular arch, which are referable to three distinct groups of Chelonians.

CHELONIA *Bellii*.—("Medals of Creation," p. 776)—Ribs and portions of the marginal border of the carapace, and plates of the plastron, with a smooth outer surface, referable to a large species of marine turtle, were among the first vestiges of Chelonians obtained from the quarries near Cuckfield in 1820. Some of these indicate a total length of three feet. The most remarkable character in the inconsiderable portions of the skeletons of this extinct reptile that have come under my examination, is the narrow dimensions to which the intercostal spaces are reduced, from the ossification and confluence of the ribs extending to within a short distance of their distal extremities. Professor Owen states that in the convexity of the under side of the vertebral ribs,

[1] Notice of the occurrence of three kinds of Chelonians in the strata of Tilgate Forest, is given in my "Fossils of the South Downs," (p. 47) published in 1822; and of Mr. Lyell's recognition of their analogy to specimens from Stonesfield.

[2] With the exception of fig. 8, Pl. V., which later discoveries have proved to belong to a Crocodilian and not to a Chelonian reptile.

and in the modifications of the form of the episternal, hyosternal, and hyposternal bones, this species offers the nearest



LIGN. 33.—DISTAL EXTREMITY OF THE RIB OF A TURTLE. TILGATE FOREST.
(*Nat. size*)
(CHELONIA BELLII.[1])
a. Apical extremity of a rib.
b. Distal portion of a costal plate.

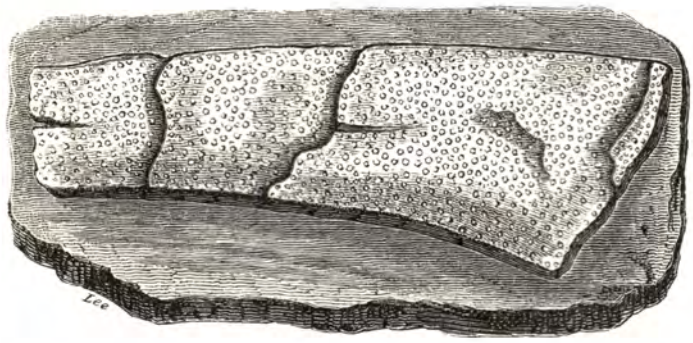
resemblance to the *Chelone planimentum* of the Harwich eocene clay.

EMYDIANS, or Freshwater Turtles, (*Platemys Mantelli.*)—*Wall-case A-B.*—Of this group of Chelonians, in which the carapace is much flatter than in the land or marine Turtles, there are the remains of a species which Baron Cuvier (to whom I transmitted specimens in 1820) supposed to be identical with one discovered in the Jura limestone at Soleure by M. Hugi, and described in "*Ossemens Fossiles*," tome v. p. 232. The proportions of the fragments discovered indicate the breadth of the carapace to have exceeded twenty inches. A fine plate of the plastron, the *left hyposternal*,[2]

[1] Named in honour of the eminent zoologist, Thomas Bell, Esq. Secretary of the Royal Society.

[2] Marked No. 2338 on the specimen, and labelled in my museum, "Sternal plate of a Marine Turtle," belongs to this species, according to the observations of Professor Owen.

in Tilgate grit, is placed with the Wealden Chelonian remains in this case.



LIGN. 34.—COSTAL PLATE OF A FRESHWATER TURTLE. TILGATE FOREST. (TRETOSTERNUM BAKEWELLI.)

($\frac{1}{3}$ *nat. size.*)

TRETOSTERNUM (*Trionyx Bakewelli.*[1])—The most numerous, and at the same time the most enigmatical remains of Chelonians, obtained in my earliest researches in the Wealden of Sussex, were fragments of very flat costal plates of the carapace of a species of freshwater turtle, having a granulated external surface, and resembling in this respect the bony case of the recent fluviatile sub-genus, named *Trionyx*, from their having but three free toes on each foot. These Chelonians are distinguished by the intercostal spaces, the ribs not being ossified throughout, and their extremities having no osseous border of support; the external surface of the carapace is covered with delicate pits or hollows, for the attachment of the soft skin, which is the only dermal integument; for the animals of this genus are destitute of scutes, and consequently the dorsal and costal plates of the carapace do not exhibit furrows or grooves, produced by the margins of the scales of tortoise-shell, as in the other sub-genera.

Such are the characters of the recent turtles, whose cara-

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[1] Notice of the occurrence of this Turtle in the Wealden was first given in my "Geol. of Sussex," 1822; it was figured and described in "Foss. Tilgate Forest," in 1827; and again, as *T. Bakewelli*, in "Geol. S. E. of England," 1833.

paces have a shagreen or pitted surface, closely resembling the granulated plates under examination; but in the latter there are deep grooves on the sculptured surface, showing that the original was protected by scutes of tortoise-shell, as in the other tribes of Chelonia.

"In the rib" (placed on the lowest shelf in Case *A*.[1]) "these imprints are very distinct, and it is observable that this costal plate, instead of being nearly of an equal width throughout, as in the freshwater and marine turtles, gradually enlarges till one termination is twice as wide as the other. This is a character observable in the land tortoises only, and therefore presents another anomaly in the structure of the fossil animal. From the slight degree of convexity of this rib, it is clear that the original was of a flattened form, like the common turtle, Testudo mydas; its shagreened surface proves its analogy to Trionyx; but the imprints of scales show that it cannot be identified with any recent species. Among the numerous portions of the osseous border of the carapace found in Tilgate Forest, we have not observed any with a shagreen surface; a negative proof that the fossil, like the recent Trionyx, was destitute of that appendage."[2]

Specimens far more perfect have since been met with; some of which are in the collection of Sir P. Egerton, and described in "Brit. Assoc. Reports." According to the present state of our knowledge of this remarkable type of freshwater turtles, the carapace was very flat and large, and its surface rugous, as in the Trionyces, but covered with dermal scutes, as in the Emydians: it therefore had not the soft integument of the existing Chelonians, to which it is otherwise nearly related.

Except in having a defensive coat of tortoise-shell, the *Tretosternum Bakewelli*, with its sculptured carapace and rudimentary marginal plates, and unossified centre of its

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[1] Figured in "Foss. Tilg. Forest," Pl. VI. fig. 1.

[2] "Fossils of Tilgate Forest," pp. 60, 61. The palæontologist engaged in establishing the nomenclature of British Fossils, will remark that the above quotation is from a work published in 1827; and that the distinctive characters are sufficiently pointed out to warrant the author in assigning a specific name, six years afterwards ("Geol. S. E. of England," p. 255), to a fossil exhumed from the strata with his own hands, and described and figured in his works alone.

plastron, must have closely resembled the existing species of Trionyces; and doubtless, like its modern prototypes, inhabited muddy deltas and estuaries, and preyed on the eggs and young of the large reptiles, and the soft bodies of the mollusks, with whose remains its bones are associated in the strata of Tilgate Forest.[1]

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[1] The TRETOSTERNUM BAKEWELLI is described as *T. punctatum* by Professor Owen in his "Report on British Fossil Reptiles," 1841; with the following remark:—"Portions of ribs of the Tretosternum punctatum, which from their specific punctation and sculpturing of the outer surface have been referred to the genus Trionyx, have been discovered by Dr. Mantell in the Wealden of Tilgate, 'Illustrations of the Geology of Sussex,' 4to, Pl. VI. figs. 1, 3, 5." Not the slightest allusion is made to my having figured and clearly pointed out the remarkable characters of this extinct Chelonian, many years before Professor Owen had written a single line on any palæontological subject.

As the original discoverer and interpreter of this Turtle, I proposed to distinguish it by the specific name *Bakewelli* ("Geology S. E. of England," p. 255), as a tribute of respect to the late Mr. Robert Bakewell, the eminent geologist, whose "Introduction" was one of the earliest and ablest English works for the student in geology. With a melancholy pleasure I once more associate the name of my lamented friend with a department of palæontology in which he felt peculiarly interested: a privilege, "*which, besides the claim of priority, is the honest result of labour devoted to the elucidation of the subject.*" *

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* (Quoted from Professor Owen's Brit. Assoc. Report, p. 163.)

CHAPTER III.

PART III.

FOSSIL BATRACHIANS AND SAURIANS.

INTRODUCTORY—TEETH OF REPTILES—VERTEBRÆ OF REPTILES—BICONVEX CAUDAL VERTEBRA—SWANAGE CROCODILE—GEOSAURUS—MACROSPONDYLUS—CROCODILUS TOLIAPICUS—CROCODILUS SPENCERI—TELEOSAURUS PRISCUS—TELEOSAURUS CHAPMANNI—ŒNINGEN SALAMANDER—PTERODACTYLES—MOSASAURUS—POLYPTYCHODON.

INTRODUCTORY REMARKS.—The fossil reptilian remains we have now to examine, consist of the bones of the skeleton, either detached, or imbedded in the rock somewhat in their original relative position,—of the osseous dermal scutes and spines, which in certain gigantic extinct saurians are greatly developed,—of the bony sclerotic plates of the organs of vision,—and, very rarely, of the cartilaginous expansions and dermal integuments of the paddles and other parts in a carbonized state. These softer tissues appear, in some instances, to have been converted into adipocire, and subsequently permeated by mineral matter.

The Gallery contains examples, more or less illustrative, of species and genera of the following orders of the class Reptilia, viz. : 1. *Batrachians*, or the Frog-tribe ; 2. *Ophidians*, or Serpents ; 3. *Lacertians*, or Lizards; 4. *Enaliosaurians*, or marine Lizards ; 5. *Pterosaurians*, or flying Lizards ; 6. *Crocodilians*; 7. *Dinosaurians*, or extinct colossal Lizards.

In the "Medals of Creation,"[1] I have given a concise exposition of the most important and easily recognisable characters of the bones and teeth, and other parts of these animals, that are met with in a fossil state, for the guidance of the collector unacquainted with the rudiments of osteology ; and to that

[1] Vol. ii. chap. xvii. pp. 688—707.

work I must refer the general reader desirous of acquiring more particular information respecting the specimens to be reviewed in the present chapter: for anatomical details, and explanations of all the technical terms employed to designate the respective parts, would extend this volume beyond the limits of a hand-book.

TEETH OF REPTILES.—The teeth, from their dense structure, are the most durable parts of the skeleton, and these organs occur even in rocks of immense antiquity, in the most beautiful state of preservation; and the various modifications of form and structure, and implantation in the jaws, observable in the existing tribes, are found in the extinct races.[1] They exhibit considerable diversity of shape, but the characteristic type is that of a simple cone, with either a rounded or pointed apex, and a single fang; for no known reptile, whether fossil or recent, has a tooth with the base terminating in more than one root, and that is never bifurcated.

These dental organs are only fitted for seizing and retaining the prey or food; for no living reptiles have the power of performing mastication. In the Crocodile the tooth has a cylindrical shank, and a conical, longitudinally striated, enamelled crown, with a ridge on each side. In the *Hylæosaurus*, the shank is cylindrical, and the crown expanded and lanceolate, with blunt margins; in the *Megalosaurus* the tooth is laterally compressed, trenchant, and bent backwards like a sabre, with serrated edges; in the *Iguanodon* the shank is subcylindrical, and the crown of a prismatic form, greatly expanded, with broad denticulated edges, and a few longitudinal ridges in front; in the *Serpents*, the teeth are very long and pointed; in the *Lizards*, may be seen every modification of the conical form, down to a mere hemispherical tubercle or plate. The *Turtles* are edentulous, i.e. destitute of teeth; their masticating organs consisting of the horny trenchant sheaths with which the jaws are covered.

There are five essential modifications in the mode of

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[1] *Teeth of Reptiles.*—See "Medals of Creation," vol. ii. p. 688.
Lower Jaw of Reptiles.—Ibid. p. 694, *Lign.* 137.
Vertebræ of Reptiles.—Ibid. p. 695.
Sacrum, &c.—Ibid. p. 699.
Dermal bones.—Ibid. p. 701.

implantation of the teeth, viz. : 1, in distinct sockets, as in Crocodiles ; 2, in a continuous groove or furrow, as in the Ichthyosauri ; 3, attached laterally by the shank to the alveolar parapet, as in the Iguanas (*pleurodonts*) ; 4, anchylosed to the base of a shallow socket, (*thecodonts*) ; and 5, attached to an osseous support without sockets or an alveolar parapet (*acrodonts*), as in the Mosasaurus.

The compound structure of the lower jaw of reptiles is also peculiar ; there are six distinct bones on each side, and these elements undergo various modifications of form and arrangement in the respective families.

Vertebræ of Reptiles.—The vertebræ, as the elements which form the spine are termed, are the most numerous and important parts of the skeletons of the extinct reptiles, that come under the observation of the palæontologist, and which present in the gigantic terrestrial saurians, extraordinary deviations from the homologous bones in the existing species.

Unfortunately, connected series of vertebræ are but rarely met with in the fluviatile deposits in which the exuviæ of the most remarkable land lizards occur ; and it is, therefore, oftentimes extremely difficult to determine whether cervical, dorsal, and caudal vertebræ, discovered apart from each other in the rocks, belong to a spinal column typical of one species or genus, or to several genera. Hence specific and generic distinctions founded on isolated bones, can only be admitted as provisional ; for in more than one instance different parts of the same vertebral column have been made the basis of three distinct genera ; and, on the other hand, a supposed generic vertebral character not unfrequently proves to be distributed through an entire family of saurians.

The fragmentary and isolated condition of the vertebræ imbedded in the Wealden strata of the South-East of England, is a sufficient excuse for error in the interpretation of a piece of bone, or in the reference of an entire bone to a particular species or genus. My own mistakes in this respect I have always unreservedly pointed out ; and it is much to be regretted that other labourers in the same department of natural history, of far higher pretensions, do not imitate the noble example of the illustrious Cuvier, and admit and correct the errors into which they have fallen by the ascription of specific and generic distinctions without sufficient

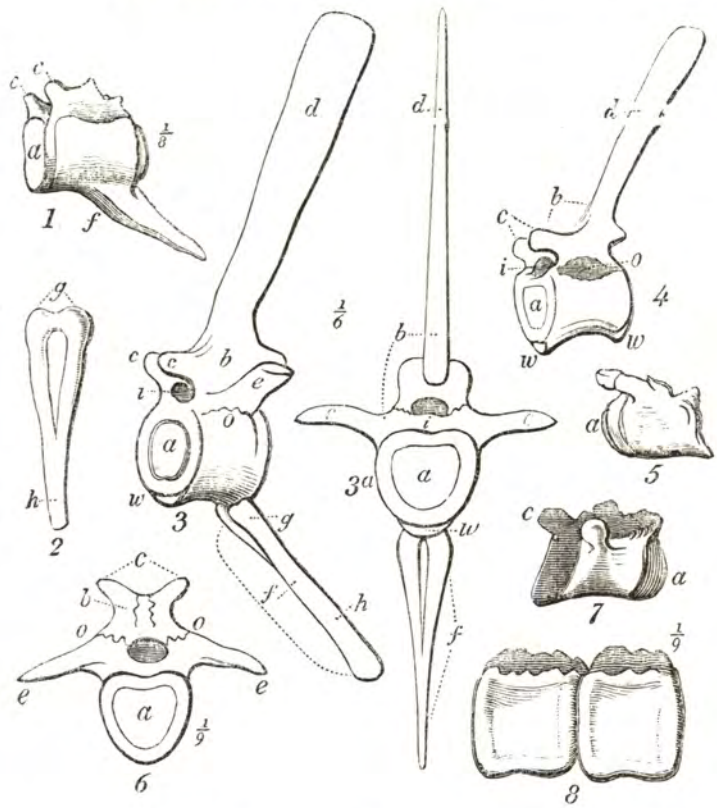
data. It is only by a strict regard to truth, and the substitution of facts for hypotheses, that the science of Palæontology can be extended, and its principles securely established.

From the great number of vertebræ in many reptiles, amounting in the individuals of some species to nearly two hundred, these bones are, perhaps, the most abundant of all the fossil relics of this class of animals. In many deposits, the vertebræ are almost always deprived of their processes, the body or centrum alone remaining, (as in *Lign.* 35, fig. 8). In other strata, entire series, with the processes more or less perfect, and in connexion with other parts of the skeleton, are found imbedded; as in the beautiful specimens of Ichthyosauri and Plesiosauri in the lias limestones and shales.

As vertebræ, or their detached processes, are frequently the only vestiges of peculiar types of extinct saurians, a few explanatory remarks are necessary to enable the reader to appreciate the interest and importance of some of the specimens in this collection, which are apparently but of very little value.

The bones composing the spine are designed to form a flexible column of support to the trunk, and afford protection to the great nervous chords constituting the spinal marrow, and which extend from the brain to the tail, giving off numerous lateral branches in their course, and conferring sensation and motive power to every part of the body. To effect this purpose, the upper part of each vertebra consists of a ring, called the *annular* part or *neural-arch*, which is composed of two processes (*Lign.* 35, *b.*), arising from each side of the body, or *centrum* (*Lign.* 35, *a.*), with which they are connected by suture, and these unite above into a solid piece, termed the *spinal* process (*Lign.* 35, *d*). On each side of the annular part there is a *transverse* process, (*Lign.* 35, *e, e.*), for the attachment of muscles; and, in some reptiles, as the Crocodiles, the ribs are articulated to these processes.

The vertebræ of the tail have, in addition to the above apophyses, an inferior spinous process, termed the *chevron-bone* (*Lign.* 35, *fig.* 2 and 3, *f*), which supports the inferior layers of caudal muscles, and is articulated to the inferior margin of the body of the vertebra, either by two distinct heads, or by the confluence of the two laminæ into a single tubercle, (as in *fig.* 2); in either case an interspace is left



LIGN. 35. FOSSIL VERTEBRÆ OF REPTILES: TILGATE FOREST.
(*The figures are reduced in the proportions specified by the fractions.*)

Fig. 1.—Caudal vertebra of an unknown reptile.
2.—Chevron bone of IGUANODON: seen in front.
3.—Caudal vertebra of IGUANODON, viewed laterally in an oblique direction.
3a.—Front view of the same.
4.—Caudal vertebra of IGUANODON, without either transverse process or chevron-bone. The letter *o* marks the deep hollow left by the removal of the transverse process, at the suture of the annular part.
5.—Vertebra of STREPTOSPONDYLUS? $\frac{1}{10}$ *nat. size.*
6.—Lumbar vertebra of IGUANODON, with the spinous process broken off.
7.—Cervical vertebra of STREPTOSPONDYLUS? $\frac{1}{10}$ *nat. size.*
c. The pair of *posterior* oblique processes.
8.—The bodies of two dorsal vertebræ of IGUANODON: viewed laterally.

The same letters refer to the analogous parts in the respective figures; with the exception of *c*, in fig. 7.

a. The body, or *centrum*, of the vertebra: the letter denotes the anterior part.
b. The annular part (*neurapophysis*), which surrounds the spinal cord.
c, c. The anterior articular or oblique processes.
d. The spinous process of the annular part.
e, e. The transverse processes, or *parapophyses*.
f. The chevron-bone (*hæmapophysis*), or inferior spine of the vertebra.
g. The single articulating head of the chevron-bone: the interspace seen in the front view, fig. 2, is for the passage of the large blood-vessels which supply the tail.
h. The spine of the chevron-bone.
i. The shaded spot, *d*, denotes the medullary cavity of the annular part.
o, o. Mark the sutures which connect the annular part with the body of the vertebra.
w, w. Indicate the place of attachment of the chevron-bone, which in the Iguanodon is always single.

for the passage of the large blood-vessels which supply the tail.

In most of the existing reptiles, (as for example the Crocodile, Iguana, &c.) the bodies of the vertebræ are concave in front and convex behind,[1] forming a series of ball and socket joints; but in many extinct genera both the articulating surfaces are flat, or slightly concave;[2] or flat in front and concave behind.[3]

In quadrupeds the annular part is anchylosed to the vertebral centre; in reptiles it is generally united by suture; but all traces of this mode of connexion are often obliterated in aged individuals. By reference to *Lign.* 35, and its description, the form, arrangement, and connexion of the different vertebral elements in certain fossil reptiles, may be easily comprehended. The bones in the spinal column of the same animal are considerably modified in the several regions of the neck (*cervical*), back (*dorsal*), and tail (*caudal*). The cervical are generally of the most complicated structure, and the caudal, the most simple.

From this exposition, the reader will perceive that every vertebra consists of the following essential parts, namely, the *body*, or *centrum*, and the *annular* part, or *neurapophysis*, so termed, because it protects the nervous chord; while a caudal vertebra has, in addition, the *chevron-bone*, called also *hæmapophysis*, from its affording a passage to the large blood-vessels.

The bodies of the vertebræ are in general solid, and consist of the ordinary osseous structure; but in certain fossil reptiles the centre of the bone is filled with calcareous spar, indicating an irregular medullary cavity; but this structure also obtains in the caudal vertebræ of mammalia, for example, in our domestic Ox.[4]

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[1] Named by Professor Owen *procœlian* vertebræ; from two Greek words, signifying concave before.

[2] *Amphicœlian*, concave at both ends.

[3] *Platycœlian*, flat in front, concave behind.

[4] I am not aware that this fact was noticed by any anatomist, till pointed out by me in a Lecture on the Structure of Fossil Saurians, delivered in the London Institution. As some Palæontologists have ascribed a specific and even generic value to this character, I annex figures of transverse and longitudinal sections of a vertebra of the

The *Sacrum*, which is the key-stone of the pelvic arch that sustains the weight of the body on the hinder extremities, is formed in existing Saurians of two vertebræ, the bodies of which are coalesced; and the posterior extremity of the distal vertebra instead of having a ball or convexity, as in all the bones composing the anterior part of the spine, is *concave*. The transverse processes are very strong, thick, and broad.

In the colossal Saurians of the Wealden and Oolite, the Iguanodon, Hylæosaurus, Megalosaurus and Pelorosaurus, (and I believe also in two other genera,) the sacrum is composed of five or six vertebræ anchylosed into a solid bony arch, as in Mammalia and Birds, with peculiar modifications in the arrangement of the apophyses; of which we shall have to treat more particularly in the sequel.

Biconvex Caudal Vertebra (*Lign.* 37).—The first caudal vertebra in the existing species of Crocodilian reptiles is remarkable on account of its double convexity, a peculiarity that appears to have escaped the observation of Baron Cuvier, and other anatomists.

In 1835, the discovery of the remains of a fossil Crocodile in the Wealden strata near Swanage, (in Case A,) led me to institute a careful examination of the vertebral column of a large Gavial, in the collection of my distinguished friend Dr. Grant, of University College; for at that time there was not an articulated skeleton of a crocodile in the Hunterian Museum. I then observed that the body of the first caudal

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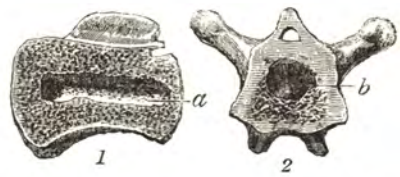
tail of an Ox, to show the relatively large medullary cavity; a fact, of which those who indulge in the luxury of Ox-tail soup may easily satisfy themselves.



Lign. 36.—Sections of Caudal Vertebræ of the Ox.
($\frac{1}{2}$ *nat. size.*)
Fig. 1. Longitudinal section.
2. Transverse section.
a, *b*, Medullary cavity in the bodies of the vertebræ.

vertebra in the adult Gavial is *convex at both ends;* a remarkable modification, required to connect the caudal series with the sacrum, in consequence of the concavity of the posterior articulation of the distal sacral vertebra; this mechanism confers freedom of motion without risk of dislocation. The value of a knowledge of this fact to the palæontologist was quickly shown by the occurrence of a biconvex vertebra among some Crocodilian bones from the Sewalik Hills, transmitted to Dr. Buckland by Major Cautley and Dr. Falconer. This bone had given rise to many vague conjectures before the announcement of my discovery of this peculiarity in the first caudal, which is the only vertebra of the series that presents such a structure,[1] and the only anterior caudal that has no chevron-bone or hæmapophysis, (see *Lign.* 37).

I must pass over other osteological characters, and proceed to describe the interesting specimens which have called forth these preliminary remarks. The student in comparative anatomy, whose interest may be awakened by these brief comments on the anatomical structure of the extinct types of

[1] On my return to Brighton, after a careful admeasurement of the different parts of Dr. Grant's fine skeleton of a Gavial, in order to determine the generic relation of the Swanage Crocodile, I was surprised to find that the double convexity of the first caudal was not mentioned in the works of Cuvier, or in those of any other author to which I had access; I therefore wrote to my kind friend, Dr. Robert Grant, and requested him to examine the skeleton; the following is an extract from his reply:—

"You are quite correct. The *first caudal* vertebra of the *Gavial*, the *Crocodile*, and the *Alligator* is, like the *last* cervical of Tortoises and Turtles, *convex at both ends* of its body. It is not so in the Monitors, nor I believe in the other families of Sauria, nor in the Chelonian reptiles.

"In a very young Gavial before me, these sacro-coccygeal surfaces are as flat as in the vertebræ of quadrupeds, while in the Crocodile and the Alligator at the same early period, the first coccygeal is as *convex anteriorly* as you have observed it in the adult Gavial. The last sacral is, of course, deeply concave posteriorly to receive the anterior ball of the first caudal vertebra. I am not aware that you have been anticipated by any one in your observations on this part of the osteology of the Gavial."

"London, 15th March, 1836. "Robert E. Grant."

To place this fact on record as a guide to future investigators, I sent a short description, with a sketch, to the "Lancet," which was published in that Journal, June, 1836.

The annexed figure, (*Lign.* 37,) represents, on a reduced scale, the

oviparous quadrupeds that peopled the islands and continents in the earlier ages of the world, should consult Cuvier's "*Ossemens Fossiles*," and the works of later writers on the subject; especially those of Professor Owen on this branch of British Palæontology.

Fossil Crocodile of Swanage. (*Goniopholis crasssidens.*)[1] *Wall-case A.*—Swanage is a little town on the east coast of the Isle of Purbeck, whose inhabitants carry on a brisk trade in the exportation of stone from the numerous quarries in the vicinity, there being a good bay and anchorage for vessels. The town stands at the mouth of the bay, about six miles E.S.E. of Corfe Castle. The coast presents a section of the Cretaceous and Wealden strata, from the Chalk to the Purbeck beds; the Portland oolite, on which the lowermost freshwater strata repose, appearing on the south. Remains of Turtles, and fishes of species peculiar to the Wealden formation, are often found; and occasionally bones and teeth of large saurians.[2]

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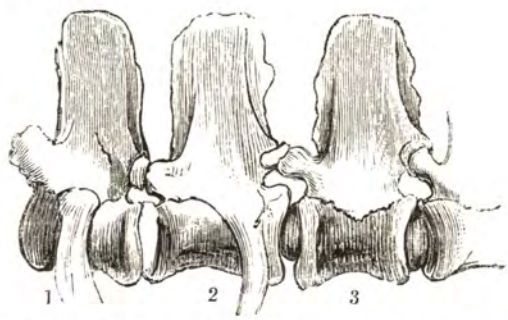
parts described, from Dr. Grant's articulated skeleton, which is 16 feet in length. I have felt it necessary to append this note, as in a recent publication the importance of a knowledge of this fact to the comparative anatomist is put prominently forth, but without the slightest allusion to the original observer.



Lign. 37.—Sacrum and First Caudal Vertebra of a Gavial. From a Skeleton, 16 feet long, in the Anatomical Museum of Professor Robert E. Grant, University College.

($\frac{1}{5}$ *nat. size.*)

1, 2. The Sacrum, consisting of two coalesced vertebræ.
3. The First Caudal Vertebra, having both the articular extremities convex.

[1] "*Goniopholis*, in reference to the rectangular form, size, number, and firm junction of the osseous scutes (φολίδες)."—Prof. Owen, British Association Reports, 1841.

[2] See my "Geological Excursions round the Isle of Wight, and along the coast of Dorsetshire:" 2d Edit. p. 345.

In the summer of 1835, the workmen employed in a quarry near Swanage, on splitting asunder a large slab of Purbeck limestone, perceiving teeth and portions of bones exposed on the corresponding surfaces of the slabs they had separated, carefully preserved the two pieces of stone: and, fortunately, my friend Robert Trotter, Esq., who was on a visit in the neighbourhood, heard of the discovery, and purchased the specimens for me.

The slabs when first received by me gave but obscure indications of the remains that careful chiselling subsequently brought to light. After much labour, I succeeded in developing the detached parts of the skeleton now visible, and fortunately without fracturing the stone by which they were concealed; consequently, the two corresponding surfaces are in a beautiful state of preservation; and being placed together in the same case, may be examined with facility; they are now as interesting groups of Crocodilian remains as have been discovered in this country.

On the left-hand slab are seen the posterior parts of the left side of the lower jaw with two teeth attached, and several detached teeth distributed about the stone; there are many ribs; numerous amphicœlian, or biconcave vertebræ, having a small irregular medullary cavity in the centre of the body of the bone; slender chevron-bones, with a bifurcated or double process of attachment, as in the crocodile; the ischium, pubis, ilium, and other parts of the pelvic arch; and a few bones of the extremities.

The vertebræ, the largest of which are nearly two inches long, are fractured across the middle, at right angles to their articulations, so that in every instance the articular ends of the body are concealed; transverse vertical sections of the centrum, with the spinous process, and long straight transverse processes attached, are the only parts visible. (*Lign.* 38. 2, 2). But several nearly perfect vertebræ of the same type, collected from the strata of Tilgate Forest, show that the articular surfaces are very slightly concave, as is the case in almost all the crocodilian vertebræ of the secondary formations. The suture uniting the annular part of the vertebræ to the body is well defined; the sacral vertebræ are beautifully displayed.

With these are the remains of the dermal cuirass, consisting of numerous scutes or dermal bones, scattered at

random among the other detached parts of the skeleton. There are, likewise, numerous scales and teeth of a small ganoid fish (*Lepidotus minor*), of a species that is common in

LIGN. 38.—FOSSIL REMAINS OF A CROCODILIAN REPTILE, FROM THE WEALDEN DEPOSITS. SWANAGE, 1835.
(*Goniopholis crassidens.*)

(*The original is 3½ feet long, and 3 feet wide.*)

1. Part of the left side of the lower jaw, with two teeth attached.
2. Detached vertebræ, fractured across, and showing vertical sections of the centrum, or body.
3. Dermal scutes—the smooth inner surface exposed.
3′. ———— showing the deeply sculptured external surface.
4. Ribs, all imperfect.
5. Chevron-bones, or hæmapophyses.
6, 6. The two pubic bones (*Pubis*).
7, 7. The two ischiac bones (*Ischium.*)
8, 8. Bones of the Pelvis; consisting of the coalesced sacral vertebræ, and the two iliac bones.

the Purbeck strata. In the small diagram, *Lign.* 38, outlines of the most important parts are given, and numbered, so as to admit of easy reference. On the opposite stone are seen

the corresponding portions of several of the bones, as well as others of which there are no traces, on the left-hand piece.[1]

Teeth of Goniopholis.—(*Lign.* 39.)—The teeth of this reptile are of the usual crocodilian type; they are cylindrical, and smooth at the base, and have a rounded obtusely conical enamelled crown, the surface of which is strongly marked by numerous well defined longitudinal grooves and ridges, with a prominent median ridge on each side, placed anteriorly and posteriorly. Teeth of this kind are not uncommon in the strata of Tilgate Forest, and other localities of the Weald of Sussex: they were described by me in 1822 ("Fossils of the South Downs," p. 50), and subsequently in the "Fossils of Tilgate Forest," (p. 64, Pl. V. figs. 1, 2, 3, 7): specimens which I transmitted to Baron Cuvier, are figured and described in "*Ossemens Fossiles*," tome v. p. 161, Pl. X.; together with vertebræ, which were supposed to belong to the same species of saurian.[2]

LIGN. 39.—A TOOTH OF GONIOPHOLIS CRASSIDENS. (*nat. size.*)

The teeth and bones vary considerably in size: some appear to have belonged to individuals not more than eight or

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[1] A lithograph of the left-hand specimen is given in the third edition of my "Wonders of Geology," 1839.

[2] "*Des os de Crocodiles des sables ferrugineux du dessous de la Craie, trouvés dans le Comté de Sussex, par M. Mantell.*" After describing the geology of that part of England from the account given in my "Fossils of the South Downs," then recently published, Baron Cuvier observes: "M. Mantell a bien voulu me communiquer quelques-uns de ses morceaux, et j'y ai reconnu, comme lui, des dents et des vertèbres appartenant manifestement à ce genre (Crocodiles).—Il se trouve parmi les vertèbres une quatrième dorsale, une du milieu de la queue, et une d'un peu plus loin, provenant d'un individu de neuf à dix pieds de long. Les vertèbres sont un peu concaves aux deux extrémités, ce qui les rapproche du crocodile de Caen, et du deuxième de ceux de Honfleur. Les dents sont pour la plupart plus obtuses même que dans nos crocodiles vulgaires, et ressemblent en ce point à la seconde du Jura que j'ai décrite ci-dessus."—*Oss. Foss.* tome v. p. 163. Paris, 1824.

ten feet in length; others are twice as large, and indicate reptiles eighteen or twenty feet long.

It is not unusual to find specimens of these teeth partly decomposed, and disclosing the successional germ; proving, that as in the crocodile, the tooth is composed of a series of cones enclosed within each other, the outer or old crown being burst by the pressure of the upward growth of the included one. Hence, at whatever age the tooth of a crocodile is removed, we find, either in the socket, or in the cavity of the old tooth, a smaller cone ready to supply the place of the latter, when broken or destroyed. This succession is very frequently repeated, and it is from this cause that crocodilian teeth in a fossil state are always so sharp and well defined, for they are as perfect in the adult and aged animals as in the young state.[1]

Dermal bones of Goniopholis.—(*Lign.* 40.)—The most remarkable character in the interesting specimen we are now examining is the dermal cuirass, of which the remains, consisting of osseous scutes, are scattered promiscuously over both blocks of stone, some having the inner, and others the external surface exposed. Several of these dermal plates are entire (one is represented in *Lign.* 40); they are six inches in length, and two and a-half in width. Fragments of these scutes are often found in the Wealden strata; and the earliest specimens I collected, from the resemblance of their corrugated surface to that of the costal plates of the carapace of the soft-skinned turtles (*Trionyces*), were figured and described as such in my "Fossils of Tilgate Forest," Pl. VI. fig. 8; that opinion being sanctioned by Baron Cuvier, who, with his characteristic liberality and kindness, sent me models of the eocene turtles of Paris, for comparison. The occurrence of similar scutes associated with crocodilian bones in the Swanage specimen, first led me to suspect their true character, which became manifest on clearing out a perfect specimen: their nature I will briefly explain.

In the loricated tribe of reptiles, as the Crocodiles, the external integument encloses numerous bony scutes, or scut-

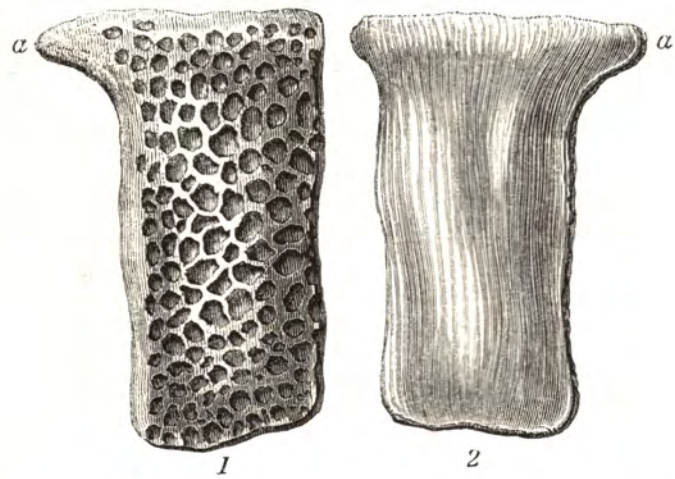
[1] There were a considerable number of teeth of crocodilian reptiles from the Wealden in my collection, but I do not know in what part of the Museum they are placed.

cheons, variously arranged, and which are the supports of the dermal scales and spines.

In the gigantic Gavial that inhabits the Ganges, and other rivers of India, and which is remarkably distinguished by its extremely slender, prolonged, beak-like muzzle, the nape of the neck is protected by a complete shield, formed of sixteen or eighteen transverse rows of dermal plates, of which there are also six longitudinal series that extend down the back.

These scutes are deeply corrugated externally, a structure adapted for the firm adhesion of the scaly integument; the largest in Dr. Grant's Gavial are $4\frac{1}{2}$ by 3 inches in dimension.

In the Swanage Crocodile the external surface of the dermal plates (*Lign.* 40, fig. 1), is covered by numerous, irregularly



LIGN. 40.—DERMAL BONE OF THE SWANAGE CROCODILE. ($\frac{1}{3}$ *nat. size.*)

1. The external surface.
2. The inner surface.
a. The lateral connecting process.

round and angular pits, or depressions, while the inner surface (fig. 2) is smooth and glossy, and finely striated by decussating lines, as in the dermal process of the Hylæosaurus.

These scutes differ from those of all known recent and fossil crocodilians in possessing a lateral conical projection (*a*, *Lign.* 40), which fits into a depression on the under surface of the opposite angle of the adjoining plate, resembling, in

this respect, the scales of the large Wealden fish, the *Lepidotus*, with which the remains of Goniopholis are frequently associated.

Numerous hexagonal and pentagonal scutes, united by marginal sutures, also entered into the composition of the dermal cuirass of this reptile, which must, therefore, have possessed a flexible and impenetrable coat of armour, capable of affording protection against the attack of any assailant.

From the structure of the skeleton of the *Goniopholis*, we may infer that the original was a powerful carnivorous reptile, resembling in its habits the existing Crocodiles and Gavials, and frequenting the rivers and marshes of the country inhabited by the colossal terrestrial lizards with whose remains its bones and teeth are generally found associated throughout the Wealden deposits of England and Germany.

Fossil Crocodilians.—As the cabinet under review contains the remains of several other species and genera of crocodilian reptiles, it will be convenient to notice them under this section, and afterwards examine the Batrachians, Pterosaurians, &c. that are placed next in order to the Swanage Crocodile above described.

The loricated, or mailed saurians, the Alligators, Crocodiles, and Gavials, are the largest living forms of cold-blooded oviparous quadrupeds. No relics of any recent species of these genera have been observed in a fossil state; but remains of Crocodilians of the existing generic types, having the spinal column composed of *concavo-convex* vertebræ, have been found in the Isle of Sheppey, on the coasts of Western Sussex and Hampshire, and other localities of the London clay.

It may be stated in general terms, that of the Crocodilians with broad muzzles, as the Cayman, and Alligator, no representatives have been found in formations more ancient than the Tertiary; those of the Secondary deposits being all referable to the division with elongated beaks, like the Gavials, which are characterised by their long and extremely narrow jaws, with teeth that are nearly of equal size, and alike in form; their feet are palmated. They inhabit the Ganges and other rivers of India, and sometimes attain a length of thirty feet. The fossil Crocodilians of the Gavial type are subdivided into two groups; the *Teleosaurus*, in which the nasal

apertures terminate in two distinct orifices, instead of being blended into a single opening as in the recent Gavials; and the *Steneosaurus*, in which the breathing canals end in two nearly semicircular vertical orifices at the extremity of the muzzle.[1]

Geosaurus (*G. Sœmmeringii*). *Wall-case A—B.* (See *ante*, p. 153.)—The remains of a small crocodilian reptile, consisting of a considerable portion of the vertebral column with the ribs, and the anterior part of the skull with the jaws and teeth, are deposited on the lowermost ledge in the angle between the Wall-cases *A* and *B*. These fossils are mentioned in the official "Synopsis of the British Museum," as the head and other parts of the *Geosaurus*, (*Lacerta gigantea*, of Sœmmering,) found in the white Lias, at Monheim, in Franconia; being the original specimens figured and described by Sœmmering, in the Transactions of the Academy of Munich. They are also figured and described by M. Cuvier, ("*Oss. Foss.*" tome v. p. 338, Pl. XXI. figs. 2—8.)

The vertebral column, in two portions, partially imbedded in fissile marlstone, is placed in the long cases in the centre; and the two parts of the cranium and jaws are in the small cases on the right hand.

The teeth of this extinct crocodilian reptile are flat, pointed, and recurved backwards like a sabre, the edges being finely serrated; there are seventeen on each side the upper jaw. The eye was very large, and the sclerotic coat protected by a zone of osseous plates, as in the Ichthyosaurus. The vertebræ are biconcave and slightly contracted in the middle; their transverse processes are very large and strong.

From the form and structure of the cranium, M. Cuvier inferred that the original held an intermediate place between the crocodiles and monitors, but was most nearly allied to the latter. The length of the reptile was probably nine or ten feet.

Macrospondylus. Wall-case B. Uppermost Shelf. — The

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[1] "In the *Teleosaurus* the nostrils form almost a vertical section of the anterior extremity of the beak; in the *Steneosaurus* this anterior termination of the nasal canal had nearly the same arrangement as in the Gavial, opening upwards, and being almost semicircular on each side." —*Dr. Buckland's "Bridgewater Essay,"* p. 252, Pl. XXV.

fossil thus labelled consists of the cranium and part of the vertebral column, with many ribs, of a small saurian reptile, from the Lias at Boll, which has been referred to a distinct genus by H. von Meyer. I have not been able to obtain any further information respecting this specimen.

Crocodilus toliapicus. Wall-Case B. [2.]—The discovery of the cranium of this species in the London clay of the Isle of Sheppey described by Baron Cuvier, afforded the first certain proof of the existence of a true crocodile in the eocene deposits of England. The specimen in the Case before us is remarkably fine: it is above two feet long, and both jaws and teeth are in a beautiful state of preservation. The recent *Crocodilus acutus* of the West Indies is stated to be the nearest living representative of this ancient tertiary species.

Crocodilus Spenceri. Wall-Case B. — A remarkably fine skull of a crocodile, two feet in length, and ten inches in width, from the Isle of Sheppey, is placed on the ledge near the specimen last described; a cranium of this species is figured in Dr. Buckland's "Bridgewater Essay," Pl. XXV.; and described in "Brit. Assoc. Report," p. 65.

Professor Owen states that the most characteristic differences which this species presents in comparison with the *Crocodilus biporcatus*, or other existing species of Crocodile or Alligator, are the larger size of the temporal holes, as compared with the orbits, the more regular and rapid diminution of the head towards the snout, the straight line of the alveolar tract, and the greater relative length and slenderness of the muzzle. It most nearly resembles the Bornean species (*Croc. Schlegelii.*)[1]

Remains of this Crocodilian reptile have been obtained from the London clay at Bracklesham, on the Sussex coast; and I have collected several vertebræ, dermal bones, teeth, and portions of the cranium, from the eocene strata near Lymington.[2]

In Mr. Dixon's collection there was a chain of eight vertebræ, including the sacral and biconvex first caudal, which is

[1] For details consult "Brit. Assoc. Report," (1841), pp. 66, 67.

[2] "Geological Excursions round the Isle of Wight, and along the adjacent coast of Hampshire," p. 163.

figured in Pl. XV. of his beautiful work on the fossils of some of the cretaceous and tertiary deposits of Sussex.

TELEOSAURUS.—To this genus belong several interesting fossils contained in the Wall-case *B.*—In reference to the general characters of the extinct Crocodiles comprised in this group, the eminent palæontologist Herm. von Meyer observes that "the form of the head approaches that of the Gavials, but the beak or mandible is longer and more slender, and the teeth more numerous: the first tooth is generally very long, and the other teeth are alternately longer and shorter. The head is from three to four feet in length. The hinder articular surface of the bodies of the vertebræ is concave; and their processes show considerable departure from those of Crocodiles. The skin was covered by broader and thicker scales than in the Crocodilians, and these scutes overlaid each other in such manner as to constitute a strong flexible coat of mail. The scales are deeply pitted externally by hemispherical depressions; and their form, structure, and arrangement, led M. Geoffroy to conclude that the living Teleosauri must have been more decidedly aquatic than the Crocodiles, and were probably marine animals.

In their general shape the Teleosauri are more slender than the Gavials, and the feet are better adapted for swimming than for walking; the fore-feet being not more than half the size of the hinder ones. This disproportion of the organs of progression, together with the scaly dermal integument, must have rendered the motions of these animals difficult on land, but in the water they could move with great facility, and there can be little doubt that these ancient gavial-like saurians inhabited the seas of the Secondary Epochs.[1]

Teleosaurus.—Wall-case B.—A cranium with the jaws and teeth most beautifully preserved, the extremity of the muzzle being entire, and exhibiting the apertures of the nostrils, is placed in the recess near the *Crocodilus toliapicus;* but I have not been able to obtain any information respecting this fine specimen. On the same ledge is the upper part of the cranium of another example of *Crocodilus Spenceri.*

[1] From "Palæologica zur Geschichte der Erde und ihrer Geschöpfe, von Hermann von Meyer." Frankfort, 1832.

Teleosaurus priscus.—Wall-case B.[1]—The beautiful reptilian fossil thus labelled, is entered in the "Museum Synopsis" as "another species of Gavial, (considered as a distinct genus, by H. von Meyer, to which he has given the name of *Æolodon*,)[2] from the lias at Monheim in Franconia, being the unique specimen figured and described by Soemmering in the Memoirs of the Academy of Munich, as *Crocodilus priscus.*"[3]

This specimen is also described by Cuvier (*Oss. Foss.* tome v. p. 120, pl. VI.) under the name of "*Gavial de Monheim.*"

It consists of a considerable portion of the skeleton of a reptile about three feet in length, imbedded in a layer of yellowish grey calcareous schist; the slab having been split asunder (as in the Swanage specimen), each of the exposed surfaces displays portions of the enclosed osseous remains. On the stone there are casts of discoidal shells, the impression of the tail of a small fish, and remains of insects. The quarry whence the specimen was obtained is worked for lithographic stones, and is celebrated for the remains of Pterodactyles, fishes, crustaceans, insects, &c. which we shall notice in the sequel.

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[1] The following diagram may assist the visitor in identifying the specimen:—

Top of Case *B*.

Teleosaurus, with the four extremities.	Cast of Mystriosaurus Egertoni; from Altdorf.

In Case *B*. [2.]

Teleosaurus Chapmanni.

Teleosaurus priscus.

Hylæosaurus: vertebral column, from Bolney, Sussex.

Hylæosaurus: from Tilgate Forest.

[2] Indicative of the alternating size of the teeth.

[3] Trans. Academy of Munich, 1814.—"CROCODILUS PRISCUS.—Rostro elongato cylindrico, dentibus inferis alternatim longioribus, femoribus dupla tibiarum longitudine."—*Soemmering.*—The description is accompanied by figures of the natural size, of which I have a copy, presented to me by the distinguished author, nearly thirty years since.

The largest slab contains the bones of the head, trunk, and tail of the animal, from one extremity to the other, but little deranged from their natural connections. The skull, however, is twisted over, and the lower jaw lies uppermost in the position in which the specimen is exposed to view. The bones of one of the hind-feet are detached from the trunk and imbedded above the anterior part of the skeleton; and the extremity of the tail is dislocated and somewhat broken. Portions of the dermal scaly covering are preserved. I will now point out the most important osteological peculiarities observable in this specimen; reminding the visitor that the upper part of the skull is the lowermost in its present position, and referring to M. Cuvier's work for those details which the scientific observer will require.

The form of the skull resembles that of the Gavial, but the bones of which it is composed present manifest differences from those of the recent species; the symphysis of the lower jaw is relatively shorter. The teeth are 106 in number, and placed in distinct sockets, as in the Crocodiles; they are more acuminated and curved, and stand out more prominently than in the Gavial, and their surface is finely striated longitudinally. There are twenty-five or six on each side the lower jaw,[1] and they are alternately longer and smaller, counting from the fourth tooth, so that the fifth and seventh are only half the height of the sixth and eighth, and so on. In the upper jaw the teeth are of equal size, except the first two, which are small, and the third tooth, which is very large. The palatine surface of the upper jaw is exposed. The occipital condyle, and the facet of the tympanic bone to articulate with the lower jaw, are distinctly shown.

There are seventy-nine biconcave vertebræ; the articular surfaces of their bodies are but slightly depressed; the cervicals have lost their transverse processes. The caudal vertebræ exceed by ten the number in the tail of any known crocodile. There are twenty-three ribs which are displaced, but are more or less entire. There are some of the bones of the pectoral and pelvic arches, namely, one of the coracoids, an ilium, ischium, and fragments of the sternum. The left hind foot is in its

[1] The *uppermost* part of the specimen as seen in the Case.

place, but detached, and the bones dislocated; those of the right foot are in natural connection, but altogether separated from the trunk, and lying above the lower jaw, according to the present position of the fossil in Case *B*. The length of the femur is double that of the tibia. The number of fingers and toes accord with those of the Crocodile. There are many dermal scutes scattered among the bones; the median dorsal ones are carinated; in one part there are twenty-six in natural apposition; the original must have been covered by a strong flexible scaly integument. In this small reptile, and in the remains of the large Swanage Goniopholis, we have instructive examples of the modification of crocodilian structure which so largely prevailed during the Wealden and Oolitic ages.

Teleosaurus Chapmanni.—Wall-case B.[1]—"The head and other parts of the skeleton of a Gavial from the Lias at Whitby, which, though correctly determined by its discoverer, Capt. W. Chapman, and also by Wooller, (Philosophical Transactions for 1758,) was subsequently mistaken for an Ichthyosaurus."[2]

The fine specimen in the lower compartment of Case *B*, appears to be the one above specified. It consists of a slab of Lias limestone, on which are imbedded the cranium and mandibles attached to a part of the vertebral column, with many ribs and dermal bones. The skull and jaws are between three and four feet in length. The head is retroverted, so that the under surface of the lower jaw is exposed.

In the upper part of the same Case there is a specimen of

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[1] The following is the arrangement of the Teleosauri in this part of Wall-case *B*:—

Uppermost.—Teleosaurus Chapmanni, 9 feet long.

Shelf.—Several portions of crania and jaws. Vertebræ and dermal bones of Teleosauri.

Teleosaurus Chapmanni.—(Philos. Trans. for 1758.) | Cast of Teleosaurus cadomensis,

On the bottom.—Portions of gigantic jaws with teeth of Gavials from the Eocene strata of the Sewalik Hills. Presented by G. H. Smith, Esq.

[2] "Synopsis of the British Museum;" p. 89.

this species of Teleosaurus, nine feet in length; the cranium is very fine, the vertebral column is arched, and almost perfect to the extremity of the tail; a row of dermal scutes extends along the dorsal region. Of the fore-limbs the humerus only remains; but of the hinder right limb, the femur, bones of the leg, and many of the feet, are preserved. This fossil is probably from the same locality as the one above described. The lias of the Yorkshire coast is celebrated for the abundance and variety of the remains of fossil plants, and of reptiles and other animals, that may be easily obtained by a little assiduity and perseverance.

There is also on the same ledge part of the cranium and jaws with teeth of another individual from Saltwich near Whitby; presented to the Museum in 1834; it is figured in Dr. Buckland's Bridgewater Essay, pl. XXV.

On the top of this Wall-case there is a much larger and finer specimen of the Teleosaurus than either of the above. The skeleton from the point of the muzzle to the end of the tail is preserved; most of the bones of the extremities are exposed, and numerous remains of the osseous dermal scutes. In the Case above the *Teleosaurus priscus*, there is an example of this species about seven or eight feet in length.

Dr. Buckland figures a specimen (pl. XXV.) which he describes as one of the finest of fossil Teleosauri yet discovered. "Its entire length, if perfect, would be about eighteen feet, the breadth of the head one foot; the snout is long and slender as in the Gavial; the teeth, 140 in number, are all small, slender, and placed in nearly a straight line. Some of the unguical phalanges that are preserved on the hind feet of this animal, show that the toes were terminated by long and sharp claws, adapted for motion on land."[1]

The anatomical structure and natural affinities of this species of saurian are fully considered by Professor Owen, in the Reports on British Fossil Reptiles, to which I must refer the scientific inquirer; it will suffice for our present purpose to state the leading characters which distinguish it.[2]

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[1] Bridgewater Essay, p. 253.
[2] British Association Report for 1841; pp. 72—80.

The cranium is broad posteriorly and square-shaped; it begins to contract anterior to the orbits, and gradually extends into a narrow depressed snout. The orbits are subcircular, and are directed upwards and outwards. The columella or ossicle of the ear is cylindrical, and relatively larger than in any known reptile. The entire length of the cranium and mandibles in some individuals was from four to five feet. The teeth are slender and sharp pointed, and amount to 140.

The spine is composed of sixty-four biconcave vertebræ; viz.: seven cervical, sixteen dorsal, three lumbar, two sacral, and thirty-six caudal. The largest vertebræ are three inches in length. The ribs possess the usual crocodilian character; the number of dorsal ribs exceeds that of any existing crocodilian, amounting to sixteen pairs. The scapulæ and coracoids correspond with those of the Crocodile, but are smaller. The humerus and bones of the fore-arm are much shorter than in the Crocodile. The femur ($15\frac{1}{4}$ inches long) is of the usual double-curved crocodilian form. The tibia and fibula (eight inches long), resemble those of the Teleosaurus priscus (*ante*, p. 178) in their relative shortness as compared with the femur. All the long bones, and even the metatarsals, are stated to have distinct medullary cavities.

The dermal scutes are arranged as in the existing gavials, both in longitudinal and transverse series: the pits on the external surface are nearly circular, and do not present the irregular forms observable in the scales of the Swanage Crocodile, (*ante*, p. 173.) The posterior margin of one scute covers the base of the succeeding one, and they overlap each other laterally; but there are no lateral points or processes as in the Goniopholis. The largest scutes are about $3\frac{1}{2}$ inches square.

Teleosaurus Cadomensis.—(*On the right of Teleosaurus Chapmanni.*)—This is a cast of the cranium and part of the vertebral column of a Teleosaurus, from the Oolite of Caen, in which locality remains of this species are common. This reptile was described by M. Cuvier as "*Gavial de Caen*," in "Oss. Foss." tome v. p. 127. It has 180 teeth; its beak, or mandible, is longer than in Teleosaurus priscus; the dermal scutes are rectangular, and thin at the margin; there are fifteen or sixteen transverse rows between the

first dorsal vertebra and the origin of the tail, and ten ranged longitudinally. It equalled in size the species above described.

MYSTRIOSAURUS EGERTONI.—(*On the top of Wall-case B.*)—The specimen thus labelled is the cast of a Teleosaurus, about four feet in length, the original of which was obtained from the Lias, at Altdorf. The cranium and elongated mandibles, the skeleton of the trunk, and the bones of the four limbs, are well displayed: there are many dermal scutes dispersed over the trunk.

The abundance of the fossil remains of this group of amphibious loricated reptiles throughout the Liassic and Oolitic formations, shows how numerous must have been these carnivorous saurians in the marshes, deltas, and estuaries of the islands and continents of those remote ages; doubtless the Teleosauri, like the Gavials of India, swarmed in the rivers and lakes, and preyed on fishes and on the feebler tribes of reptiles that inhabited the waters.

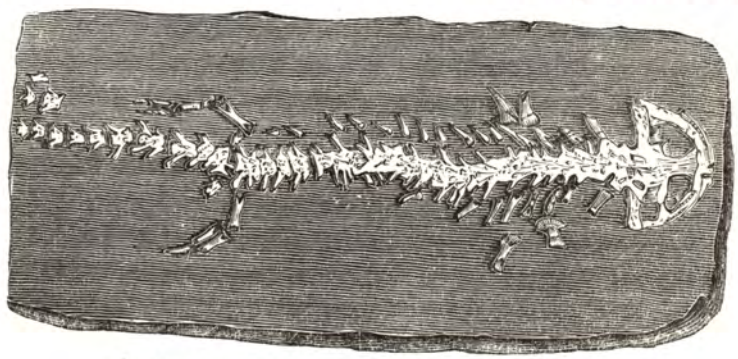
FOSSIL BATRACHIANS.—The reptiles termed *Batrachians* are characterised by the transformation which they undergo in the progress of development from the young to the adult state; the Frog, Toad, and Newt, are familiar examples of this order. Their organs of aerial respiration consist of a pair of lungs; but in youth they are provided with gills, supported as in fishes, by cartilaginous arches. These organs disappear in most species, when the animals arrive at maturity; but in a few genera, as the *Siren* and *Proteus*, they are persistent. The skeletons of these reptiles present corresponding modifications. The skull is, for the most part, much depressed, and the cerebral cavity small; it is united to the vertebral column by *two* distinct condyles, situated on the sides of the occipital or cranio-spinal aperture. The vertebral column, which in some genera (as for example, in the frog) is very short, and reduced to eight or ten bones, is composed in the higher organised Batrachians of concavo-convex vertebræ, as in the Crocodile; but in the lower types, as the Siren, Proteus, and Axolotl, the vertebræ are biconcave, as in numerous fossil saurians. The ribs are rudimentary; a condition which has relation to the mode of reproduction in these animals. Some of the Batrachians are edentulous, like the Turtles, but others have numerous small, conical, uniform, closely-arranged teeth,

placed either in a single row, or aggregated like the rasp-teeth in fishes.

The skeletons, vestiges of the soft parts, and imprints of the feet of several genera of Batrachians, occur in various tertiary deposits, and, like the existing races, belong to fresh-water or terrestrial species. In the pliocene strata on the banks of the Rhine, and in the papierkohle of the Eifel, many specimens of fossil frogs, toads, and newts, have been discovered. But by far the most remarkable of the remains of this order are obtained from Œningen, and a specimen from that place, deposited in the case whose contents are now under review (*ante p.* 153), requires especial notice.

Fossil Salamander of Œningen.—(*Wall-case A-B.*)—Among the tertiary lacustrine deposits of the continent, that of Œningen, near Constance, has long been celebrated for the perfection and variety of its organic remains, and particularly for Batrachian reptiles. A short, but graphic memoir, by our distinguished countryman, Sir Roderick Murchison, presents, in a few lines, the history of these ancient lacustrine deposits.

The Rhine, in its course from Constance to Schaffhausen, cuts through the tertiary marine formation, called the *molasse*, which rises into hills from 700 to 800 feet high, on each side



Lign. 41.—Fossil Salamander of Œningen.
(Cryptobranchus Scheuchzeri,)
(*The original is three feet in length.*)

of the river. On the right bank, a little above the town of Stein, is the village of Œningen, near which, in a basin, or depression of the molasse, there is a series of deposits, composed of laminated marls, and cream-coloured fetid limestone, amounting in thickness to between thirty and forty feet.

In these marls are imbedded the foliage and stems of various kinds of dicotyledonous trees, shells, remains of insects, crustaceans, fishes, turtles, and of large batrachians. These fresh-water beds have manifestly been accumulated in a lake at some very remote period, for their deposition must have long preceded the present condition of the country, as by far the greater number of the animals and plants are either extinct forms, or belong to species not known as indigenous in Europe; and the Rhine has worn a channel through the entire series and the molasse on which they are superposed, to the depth of several hundred feet.[1]

In the early part of the eighteenth century, the fossil Batrachians of Œningen, deeply interesting as they are to the palæontologist, acquired far greater notoriety than they would ever have obtained as objects of scientific research, in consequence of the opinion which then generally prevailed that all petrifactions had been produced by an universal deluge; and in 1725, the fancied resemblance of a cranium attached to a portion of a skeleton, discovered in the quarry at Œningen, to a human skull pressed flat, led M. Scheuchzer, an eminent physician of his day, to declare, that at length the petrified remains of one of the sinful individuals who had perished in that catastrophe were brought to light! Under this delusion he published the well-known treatise entitled, "*Homo diluvii testis et theoscopos.*"[2] This memoir contained an excellent figure of the fossil skeleton, which the author described as "the remains of one of that accursed race which was overwhelmed by the waters of the deluge, and whose bones and flesh were incorporated into stone."

The rounded form of the head, the size of the orbits, and other batrachian characters of the supposed "*petrified man*," were, however, so obvious from Scheuchzer's own figure and descriptions alone, that the true nature of the original was suggested by M. Cuvier, before he had seen any of the fossil remains. In 1811, Cuvier visited the Teylerian Museum at

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[1] Sir Roderick Murchison, on the Lacustrine deposits of Œningen, "Geol. Trans." vol. iii. p. 277, and "Geol. Journal," for 1846, p. 54.

[2] "*The* MAN *who had witnessed the Deluge, and beheld God.*" A brief notice of Scheuchzer's *fossil man* was published in the "Philos. Trans." for 1726, vol. xxxiv. p. 48.

Haarlem, in which Scheuchzer's specimen was preserved, and obtained permission to remove such parts of the stone as were likely to conceal any characteristic bones; and, as he had predicted, the anterior part of the skeleton of a large aquatic Salamander, with remains of the fore-legs, was exposed to view.[1]

The specimen in the Case before us, (of which a reduced figure is given in *Lign.* 41,) originally belonged to Dr. Ammann, of Zurich, and was examined by Baron Cuvier when in England.[2] It consists of the cranium, vertebral column, bones of the anterior and posterior extremities, and vestiges of the tail. The skull, which is pressed flat, nearly equals in size that of a man; around the semicircular jaws there are the remains of a double row of very fine teeth: the orbits are large; the occipital condyle is double; the remains of the posterior horns of the *os hyoides* are seen on each side of the occiput. There are nineteen or twenty dorsal, and sixteen caudal vertebræ. The ribs are very short, as in all Batrachians. The scapula and humerus are exposed on each side the anterior part of the spine; the femora, parts of the tibia, and fragments of the pelvis are also visible. The result of Baron Cuvier's investigations proved that the original of the celebrated Œningen fossil was an aquatic Salamander of a gigantic size in relation to all known existing species of the genus.[3]

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[1] "*Ossemens Fossiles,*" tome v. p. 437. The removal of the stone from the concealed parts was made by M. Cuvier in the presence of the officers of the Teylerian Museum. "Nous avons placé devant nous un dessin du squelette de la Salamandre, et ce ne fut pas sans une sorte de plaisir, qu'à mesure que le ciseau enlevoit un éclat de pierre, nous voyons paroître au jour quelqu'un des os que ce dessin avoit annoncé d'avance. C'est ainsi que cette table de schiste, gravée et régravée vingt fois, depuis un siècle comme elle l'est, Pl. XXV. 2, fut mise dans l'état où on la voit, Pl. XXVI. 2. 11."

[2] It is figured in "*Oss. Foss.*" tome v. Pl. XXVI.

[3] The most remarkable specimen from the quarry at Œningen that came under my own observation, was the almost perfect skeleton of a carnivorous terrestrial quadruped, which was purchased of the quarrymen by Sir Roderick Murchison, in 1828. As is usually the case with the bones imbedded in those lacustrine limestones, this skeleton was invested with a hard calcareous crust, so that the general outline of the concealed bones was alone visible. At the request of my distinguished friend, I undertook the development of this choice relic, and after devoting the leisure hours of some weeks, succeeded in completely

PTERODACTYLES.—*Flying Reptiles.*—*Wall-case A-B.*—(*ante* p. 153.)—It was not merely in magnitude, observes the illustrious Cuvier,[1] that Reptiles stood pre-eminent in ancient days, but they were distinguished by forms more varied and extraordinary than any that are now known to exist on the face of the earth. Among these extinct beings of ages incalculably remote, none are more marvellous than those we are about to examine—the *Pterodactyles* (wing-fingered), which had the power of flying, not by means of their ribs, like the *Draco volans*, nor by a membrane stretched over four elongated fingers, with a rudimentary thumb, as in bats—nor by a wing without distinct fingers, as in birds—but by a wing sustained principally on a very elongated toe, while the other members preserved their normal shortness, and were armed with claws; and with this remarkable conformation were associated a long neck, and beaks armed with teeth.

With the exception of the unique specimen of Pterodactyle from Lyme Regis, and a few detached bones from the Wealden (collected by the author), the Museum only contains casts of the remains of this extraordinary tribe of reptiles. The specimens from which these models were taken, were obtained from the lithographic stone of Solenhofen, in which bones of Pterodactyles are associated with fossil dragon-flies and other insects. The following are figured and described by Goldfuss, viz.: *Pterodactylus longirostris, P. brevirostris, P. Munsteri,*[2] *and P. crassirostris.*

The extinct beings referred to this genus, and of which nearly twenty species are now determined, varying in size from that of a snipe to species with wings sixteen feet in

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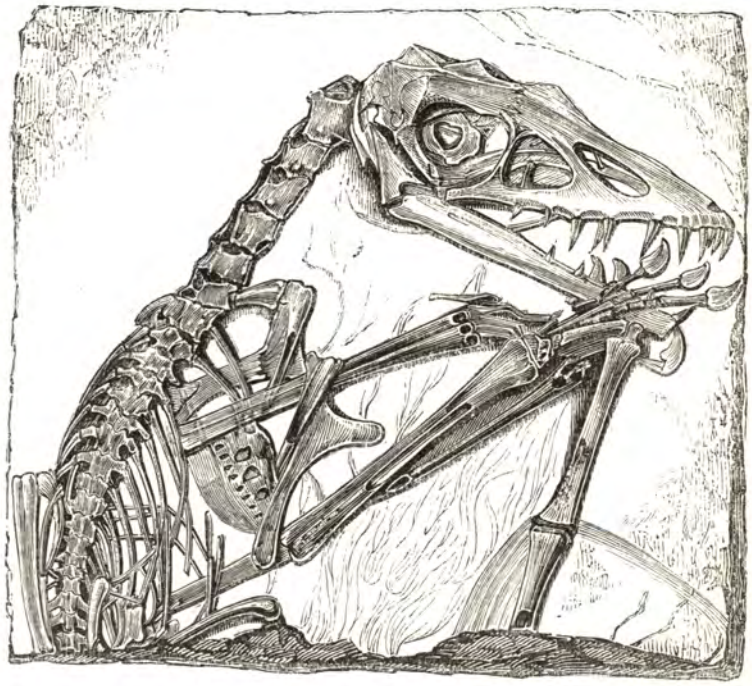
exposing the skeleton of a FOX, closely related to the common species, but with stouter limbs, and more elongated feet, and presenting other specific differences. This specimen of *Vulpes Œningensis*, is figured in "Geol. Trans." vol. iii. Pl. XXXIII. and is now in the private collection of Sir Roderick Murchison; it is certainly one of the most interesting relics hitherto discovered in the celebrated locality of the *Homo diluvii testis*. I would refer the reader interested in the history of the ancient lake of Œningen, to Sir Roderick Murchison's Memoir above cited.—"Geol. Trans." *new series*, vol. iii. pp. 277—290.

[1] Cuvier, "Oss. Foss." tome v. p. 358. Art. vi. "Ce n'étoit pas seulement par la grandeur que la classe des reptiles," &c.

[2] "Reptilien aus dem lithographischen Schiefer," von Dr. Goldfuss. The figures given by Goldfuss, and Count Munster, of these specimens, have been copied into almost every subsequent work on fossil remains.

expanse, have a remarkably small skull, with beaks furnished, in some species, with upwards of sixty sharp-pointed teeth, and generally very long. The teeth are simple, of a conical form, recurved, and implanted in distinct sockets, with considerable intervals between them. The orbits are very large, and the neck elongated. The sternum and pectoral arch are



LIGN. 42.—PTERODACTYLE, FROM SOLENHOFEN. ($\frac{1}{3}$ *nat. size.*)
(PTERODACTYLUS CRASSIROSTRIS.)

constructed as in reptiles. The peculiar organization of the fore-foot, and which entirely differs from that of any other reptile, whether recent or fossil, consists in the great extension of the fore-finger, which is composed of five bones, and exceeds in length the entire spinal column; the other digits are of the ordinary relative proportions, and armed with claws.[1] Impressions of the delicate membranous expansion, or wing, which this finger was designed to support, are occasionally

[1] There are excellent figures of Pterodactyles in Dr. Buckland's "Bridgewater Essay," Pl. XXI. and Pl. XXII.

observed on the stone surrounding the phalangeal bones (as in *Lign.* 42).

The nature of the original animal was traced by Baron Cuvier with his accustomed terseness and perspicuity; and later discoveries, though enlarging our knowledge of this remarkable order of reptiles, and presenting us with far more colossal forms than could have been rationally predicated, have added nothing of importance to the original sketch by the master-hand.

"The Pterodactyle," observes M. Cuvier, "was an animal which in its osteology, from the teeth to the extremities of the claws, and from its skull to the end of the tail, presented the classic characters of the saurians. We therefore cannot doubt that it had the same modifications in the integuments and soft parts; their dermal covering, circulation, organs of generation, &c. At the same time, it was provided with large membranous wings, and its powers of flight must have far exceeded those of the *Draco volans*, the only existing reptile that can traverse the air, and probably equalled those of the Bat. It doubtless could flit and soar on the wing as long as the strength of its muscles permitted, and suspend itself to trees or rocks by its short unguiculated toes. Its position, when in repose, would probably be like that of birds, on its hind legs, with the neck straightened and curved back, to preserve its equilibrium."

PTERODACTYLUS MACRONYX.—*Wall-case A-B.*[1]—These unique remains of a species of Pterodactyle, which, when living, was about the size of a raven, were discovered in 1828, by the late Mary Anning, the well-known intelligent collector of the fossils from the liassic deposits that form the cliffs along the coast of Dorsetshire, near Lyme Regis. I have not heard that any other relics of this species have been met with.

This specimen was figured and described by Dr. Buckland in "Geol. Trans." vol. iii. Pl. XXVII. with the specific name *macronyx*, suggested by the great length of the claws.[2] It consists of a few fragments of the cervical and dorsal vertebræ, and three caudals; the scapulæ and coracoids; and the bones

[1] Figured and described by Dr. Buckland in "Geol. Trans." vol. iii. *new series*, p. 217.

[2] The specimen was purchased of Miss Anning by the Trustees of the British Museum.

of the arms, and fingers, more or less displaced. These several parts are enumerated by Dr. Buckland as follows :—

"One cervical vertebra, ¾ of an inch in length; near this bone are small cylindrical ossified tendons, resembling the tendons which run parallel to the caudal vertebræ of rats.

Dorsal and lumbar vertebræ, in a fragmentary state.

Three caudal vertebræ.

Two scapulæ, or omoplates, long and narrow, as in crocodiles.

Two coracoids, large, as in birds, for the support of the wings in flight.

Sternum, broken and indistinct.

Humeri. The right humerus and scapula are much displaced; the left humerus, and other bones of the left wing, are nearly in their natural juxta-position.

Fore-arm: there are no traces of an ulna.

Carpus: in the left, four bones are well preserved, three in contact with the radius, the fourth with the largest metacarpal. The right carpal bones are all dispersed.

Metacarpals; first, second, and third of the right hand, and also of the left; and the fourth of each hand supporting the respective wing-fingers.

Three fingers of the left hand, terminating in long claws; there are two phalanges in the first, three in the second, and four in the third finger, as in crocodiles.

All the bones of the first and third fingers of the right hand.

First bone of the fourth or wing-finger; there is no vestige of a fifth finger.

Pelvis: the three bones of the right side, viz., the ilium, ischium, and pubis, are very distinct.

The two femora; the right one displaced.

The tibiæ; the left one compressed: there are no traces of fibulæ.

Tarsus, but faintly indicated.

Metatarsus; four of the left foot distinct and undisturbed, their under aspect being exposed.

Phalanges of the left toes, the claws wanting.

Toes of the right foot, much displaced; one claw only remains.

The length of the foot, and of the tibia and femur, shows that the animal must have stood firmly on the ground, on which, probably, with its wings folded, it moved after the manner of birds. It could, perhaps, also perch on trees, and cling to their branches by means of its feet and toes, like birds and lizards."[1]

WEALDEN PTERODACTYLES.—*Wall-case A-B.*—In the Wealden deposits, and likewise in the Stonefield calcareous slate,

[1] Dr. Buckland. "Geol. Trans." p. 222. The above details are inserted for the use of the scientific visitor who may be desirous of examining this unique specimen.

fragments of bones of such tenuity as to indicate that they belonged to animals capable of progression through the air, are not uncommon. Their occurrence in the Wealden deposits was first noticed in my earliest work, "On the Geology of Sussex;" but, although thirty years have since elapsed, I have not seen a specimen with articular extremities so perfect as to demonstrate with certainty whether it belonged to a bird or to a flying reptile. In the Case before us there are a few portions of long bones which are probably metacarpals and phalangeals of pterodactyles; and in some of the closed cabinets there are a few specimens more illustrative. There is one bone, especially, which was formerly supposed to be the tarso-metatarsal of a bird, but has since been ascertained to be a humerus, and, probably, of a Pterodactyle; although there are certain points in which it unquestionably differs from the arm-bone of any flying reptile hitherto observed.

In the absence of obvious distinctive osteological characters, it was hoped that an investigation of the intimate structure of these enigmatical remains would throw light on the subject, and that the microscopical examination of the most characteristic bones by Mr. Quekett and Mr. Bowerbank might afford a solution of the problem.

In a paper communicated to the Geological Society by Mr. Bowerbank, that able observer affirms that there is a recognisable difference in the form and proportion of the bone-cells in birds and reptiles, which he believes to be constant, and by which the smallest fragment of bone may with great probability be referred to its proper class.

In *birds*, under a power of 500 linears, Mr. Bowerbank found the cells to have a breadth in proportion to their length, as one to four or five; while in *reptiles* the length exceeds the breadth ten or twelve times. For example, in the albatross the width of the cell is one-fourth the length, and in the crocodile one-twelfth.[1] Applying this test to the bones supposed by Professor Owen to be those of a bird allied

[1] Professor Owen remarks, "Such a statement as that these cells in *Birds* have a breadth, in proportion to their length, of from one to four or five, while in *Reptiles* the length exceeds the breadth by ten or twelve times, *only betrays the limited experience of the assertor;*" and he quotes "*Mantell's Wonders of Geology*," vol. i. p. 441. Now as the statement in my work was submitted to Mr. Bowerbank's revision before it was printed, the amiable Professor has missed his mark, and hit

to the albatross,[1] Mr. Bowerbank pronounced them to belong to a Pterodactyle ; probably to the colossal species (named by him *P. giganteus*), of which he had obtained jaws with teeth, and other remains, from the same chalk quarry ; a conclusion which has since been satisfactorily established.

On the other hand, certain bones from the Wealden and Oolite are regarded both by Mr. Quekett, and Mr. Bowerbank, as exhibiting unequivocally a structure peculiar to birds.

With regard to the value of such evidence, I would venture to express my opinion, that although in the entire absence of more obvious and certain diagnostic characters, it would be unsafe to admit the relative proportions of the bone-cells as conclusive proof, it is not unreasonable to infer that the intimate structure of the solid parts of the skeleton may have relation to the peculiar organisation of a class, and that the microscopic test, if applied with due caution, will prove an important auxiliary in the interpretation of the true nature of the fossil bones of unknown animals.

Some of these presumed birds' bones are so extremely thin

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the distinguished Honorary Secretary of the Palæontographical Society, to whose indulgent consideration I therefore leave him.*

[1] These bones from the Kentish Chalk are described in Professor Owen's "BRITISH MAMMALS AND BIRDS," under the name of "CIMOLIORNIS DIOMEDEUS. *Long-winged Bird of the Chalk*," "*Bird allied to the Albatross*," (*Diomedea*). In the late Mr. Dixon's work, edited by Professor Owen, and published last year (1850), he again figures the specimen (though not a Sussex Fossil), and affirms, "I have yet obtained no evidence which shakes my original conclusion, that the bone is part of the shaft of *a humerus of a longipennate bird, like the Albatross*." (Dixon, p. 402.) And after commenting on Mr. Bowerbank's observations, he remarks, "When such obvious ornithic characters as these, and especially those of the trochlear end of the bone, determine their nature," &c. And yet Professor Owen accuses me of "misrepresenting him,"† and of being guilty of an "*unamiable exaggeration*"† of his mistake, because, in a popular work, "The Wonders of Geology," I stated that he had *regarded the bone as belonging to an extinct species of Albatross*," using the word *species* in its general sense, as a *sort*, or *kind*. If I had written "a species of the genus *Diomedea or Albatross*," it might have borne the interpretation Professor Owen now affects to put upon it. The same *unamiable* expression was employed in my "Medals of Creation" (p. 804), published seven years ago, and then gave no offence!

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* See Professor Owen's "Fossil Reptilia of the Cretaceous Formation," —Monographs of the Palæontographical Society, 1851, p. 83.

† Ibid. p. 82—p. 83.

and fragile, as to render it extremely improbable that they could have sustained such an instrument of flight as the powerful wing of the Albatross; their tenuity is indeed such as to suggest their adaptation to support an expanded membrane rather than pinions.[1]

I have recently collected from the Wealden strata of Tilgate Forest some fragments of very large cylindrical bones, the walls of which are extremely thin, and unquestionably belong to Pterodactyles.

In concluding these notes on the flying Reptiles, I may add that Mr. Bowerbank has procured from the Kentish chalk, portions of jaws with teeth, more colossal than any previously known: some portions of the upper maxilla prove the total length of the head to have been upwards of sixteen inches; and the bones of the anterior extremity indicate a width of from sixteen to eighteen feet, from the extremity of one wing to the other!

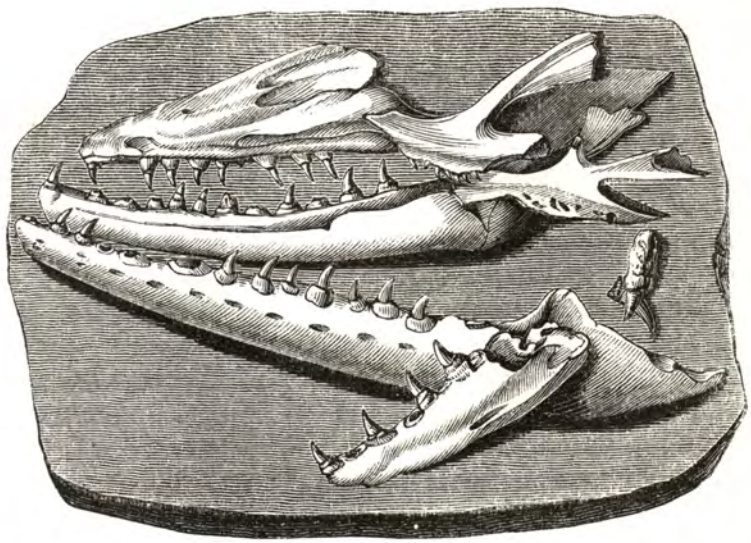
The *Mosasaurus*, or Fossil Reptile of Maestricht.—*Wall-case B.*—Maestricht, a large city in the interior of the Netherlands, situated in the valley of the Meuse, stands on a series of calcareous arenaceous deposits belonging to the Upper Chalk, and which gradually pass below into the pure white chalk with bands of siliceous nodules. Extensive quarries have for many centuries been worked in the sandstone, especially in the eminence called St. Peter's Mountain, which is a cape or headland between the Meuse and the Jaar, formed by the termination of a range of hills that bounds the western extremity of the river valley. The mountain commences at the distance of a mile south of the city, and extends in a direction towards Liege for about three leagues; it presents an almost perpendicular escarpment towards the Meuse.

The calcareous freestone, which is extensively quarried, is soft and easily cut when first removed, but dries and hardens by exposure to the air; the total thickness of the strata is above five hundred feet.

[1] A new part of the "Palæontographical Monographs" has just appeared; in which, commenting on this idea, Professor Owen states that the wings of the Pterodactyles were composed of *leather!* Start not, gentle reader!—here are the very words. "It was reserved for the Author of the 'Wonders of Geology' to prefer the *leathern wings of the Bat and the Pterodactyle* as the lighter form."—*Prof. Owen, "Pal. Mon."* 1851. p. 83.

From the extensive works that have so long been carried on, immense quantities of stone have been removed, and the centre of the mountain is traversed by galleries, and hollowed by vast excavations. Innumerable marine shells, corals, and crustaceans, bones and teeth of fishes, and remains of turtles, are imbedded in this sandstone, and as the friable character of the rock admits of the easy extrication of the fossils, they are obtained in great perfection.[1]

But the organic remains for which the strata of St. Peter's Mountain are most celebrated, are the bones and teeth of an



LIGN. 43. REMAINS OF THE JAWS OF THE FOSSIL REPTILE OF MAESTRICHT. (*Mosasaurus Hoffmanni.*)
(The original is 4½ feet by 2½ feet.)

enormous lizard, to which our eminent countryman, the Rev. W. D. Conybeare, gave the name of Mosasaurus, or Lizard of the Meuse.

The discovery of some remains of this animal had in the middle of the last century drawn the attention of naturalists to these quarries, and in 1770 M. Hoffman, the military surgeon attached to the Fort, who had long been an assiduous collector

[1] See "Wonders of Geology," p. 309.

of the fossils of the vicinity, had the good fortune to obtain a specimen which has conferred an enduring celebrity on his name.

Some workmen, on blasting the rock in one of the caverns of the interior of the mountain, perceived to their astonishment the jaws of a large animal attached to the roof of the chasm. The discovery was immediately made known to M. Hoffman, who repaired to the spot, and for weeks presided over the arduous task of separating the mass of stone containing these remains, from the surrounding rock. His labours were rewarded by the successful extrication of the specimen, which he conveyed in triumph to his house. This extraordinary discovery, however, soon became the subject of general conversation, and excited so much interest, that the Canon of the cathedral which stands on the mountain resolved to claim the fossil, in right of being lord of the manor; and succeeded, after a long and harassing lawsuit, in obtaining this precious relic. It remained for years in his possession, and Hoffman died without regaining his treasure, or receiving any compensation. At length the French Revolution broke out, and the armies of the Republic advanced to the gates of Maestricht. The town was bombarded; but at the suggestion of the committee of savans who accompanied the French troops to select their share of the plunder, the artillery was not suffered to play on that part of the city in which the celebrated fossil was known to be preserved. In the mean time, the Canon of St. Peter's, shrewdly suspecting the reason why such peculiar favour was shown to his residence, removed the specimen, and concealed it in a vault; but when the city was taken, the French authorities compelled him to give up his ill-gotten prize, which was immediately transmitted to the Jardin des Plantes, at Paris, where it still forms one of the most striking objects in that magnificent collection.[1]

The beautiful model in Case *B*, is a faithful representation

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[1] Faujas St. Fond, from whose beautiful work on the Fossils of St. Peter's Mountain (*Histoire Naturelle de la Montagne de St. Pierre*) the above account is taken, observes with much *sang froid*—"*La Justice, quoique tardive, arrive enfin avec le temps.*" The reader will probably think that although the reverend Canon was justly despoiled of his ill-gotten treasure, the French Commissioners were but very equivocal representatives of *Justice!*

of the original, and was presented to me by Baron Cuvier in 1825. It is four and a half feet in length, and two and a half in width. It consists of both jaws, with numerous teeth, (the pterygoids bearing teeth as in the Iguanas,) and the *os quadratum;* and there are likewise fragments of costal processes, and one of the metatarsal or metacarpal bones: two of the large echinoderms that abound in the Maestricht deposits are imbedded in the block. The parts preserved in this celebrated specimen are the following:—

The superior maxillary, or jaw-bone, of the right side, with eleven teeth; seen on its inner aspect.

The anterior part of the upper maxillary bone of the left side, which is displaced, and lies across the posterior part of the left ramus of the lower jaw.

The right pterygoid, with eight teeth.

The left pterygoid; all the teeth are wanting.

The premandibular part of the left ramus of the lower jaw, with fourteen teeth, seen on its outer aspect: a row of ten or twelve vascular foramina runs parallel with the alveolar ridge.

The right ramus of the lower jaw, with the teeth, seen on the inner aspect; the posterior part is somewhat concealed by the palatine bones.

The left os quadratum, or tympanic bone, lying above the concave articular facet of the lower jaw.[1]

The crown of the tooth of the Mosasaurus is of a pyramidal form, slightly recurved backwards, with a smooth coat of enamel; the largest is from $2\frac{3}{4}$ to 3 inches in length. The tooth expands at the base into a large conical mound or root ($1\frac{3}{4}$ inch in diameter), which is anchylosed to the summit of the alveolar ridge; a mode of implantation that is termed *acrodont.* The outer face of the crown is very slightly convex, and separated by two sharp crests from the inner, which is semi-conical. The pulp cavity is generally found open in the centre of the base of the crown; and the germ of the successional tooth appears on the inner side of the expanded base. The teeth of the pterygoid bones are symmetrical, their transverse section being elliptical.

Part of a lower Jaw of Mosasaurus.—On the ledge over the specimen above described is placed a very fine example

[1] For details, consult "*Ossemens Fossiles,*" tome v. p. 319. I cannot explain why the tympanic bone, which is so striking an object in the model, is omitted in the figures of Faujas St. Fond, Cuvier, &c. and in the hundred engravings of this fossil that have since appeared.

of the premandibular part of the lower jaw, with fifteen teeth, seven of which have the enamelled crowns perfect. Near it there is a fragment of another jaw with three mature teeth, and the germs of as many successional ones. These valuable fossils were presented to the British Museum by the distinguished Dr. Peter Camper in 1784.

Vertebræ of Mosasaurus.—The only other parts of the skeleton of the Maestricht reptile in the collection, are a few vertebræ placed in the recess above the *Geosaurus* (*ante* p. 153), which exemplify the general character of the spinal column; they present the ordinary structure of the vertebræ in the existing lizards and crocodiles, the body being concave in front and convex behind, and the neural arch united to the centrum by suture.

The entire vertebral column appears to have consisted of 131 vertebræ, of which 97 belonged to the tail. The structure of these elements of the spine is minutely described, and their homologies considered, in the classic work on the fossil vertebrata, to which the collector who may obtain any specimens of this kind should refer.[1]

The peculiar character of the posterior caudal vertebræ requires, however, a brief notice, in consequence of the interesting discovery which I had the good fortune to make in 1820, of the occurrence of remains of this genus in another division of the cretaceous formation, and far from the only locality previously known. The posterior caudal vertebræ of the Mosasaurus differ from the anterior by the want of transverse processes; these form a large proportion of the tail. Their faces are elliptical, at first transverse, and then more and more compressed at the sides. A great number are destitute of chevron bones, and in many this apophysis is not articulated to the body, but soldered to it, so as to form a part of the bone itself; and it is attached,

LIGN. 44.
TWO CAUDAL VERTEBRÆ OF THE MOSASAURUS STENODON.
CHALK, LEWES.
($\frac{1}{3}$ *nat. size.*)

[1] "*Ossemens Fossiles,*" tome v. pp. 326—334.

not to the juncture of two vertebræ, nor to the extremity of the body, but to the middle of the centrum.[1]

VERTEBRÆ OF MOSASAURUS, *from the chalk near Lewes.*—(*M. Stenodon.*)—*Wall-case A-B.*—On the recess above the specimens of Geosaurus, is a small block of chalk, to which are attached two caudal vertebræ, possessing the characters above described, and by which I was enabled to identify them with the corresponding bones of the celebrated Maestricht reptile, of which I had then read, but never, in my most sanguine moments, had indulged the hope of finding any vestiges in my native hills.[2] A posterior dorsal vertebra from the same locality is placed near them; I have subsequently obtained a caudal vertebra imbedded in flint (from near Brighton); a few other portions of the vertebral column have, I believe, been collected from the Sussex chalk since my removal from Sussex. The remarkable character above pointed out, of the coalescence of the chevron-bone with the body of the vertebra, is well shown in these two caudals from Lewes. M. Cuvier observes, that there is no known reptile in which this bone is soldered to, ("*soudé*"), and makes a part of, the centrum; it is a character peculiar to fishes, and must have greatly augmented the solidity of the tail.

No teeth similar to those in the jaws of the Mosasaurus have been obtained from the English chalk; but some large smooth conical teeth of an acrodont reptile, symmetrically elliptical like the pterygoidal teeth of Mosasaurus, were found in the same stratum as the vertebræ, and are probably referable to the same species. In 1831, a portion of the lower jaw with teeth of a similar character, was found in the chalk near Norwich, and of which I received drawings from the late Mr. Samuel Woodward. Other specimens of equilateral

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[1] "Elles forment une grande partie de la queue, et les faces de leur corps sont en ellipses, d'abord transverses, et ensuite de plus en plus comprimées par les côtes. *L'os en chevron n'y est plus articulé, mais soudé, et fait corps avec elles.*"—Ossemens Foss. loc. cit. p. 327.

[2] In "The Fossils of the South Downs; or, Illustrations of the Geology of Sussex," 1822, there are figures and descriptions of these specimens, pp. 242—246; tab. xxxiii. and xli. I would especially direct the observer's attention to the deep incision observable on the posterior vertebra in this specimen, which must have been made before the bones were imbedded in the chalk.

teeth anchylosed to the alveolar ridge of the mandibular bone, have been discovered; and assuming the probability that these jaws, teeth and vertebræ, of the Mosasaurian type belonged to the same genus, but differed specifically from the Maestricht animal, Mr. Charlesworth proposed to distinguish it provisionally by the name of *Mosasaurus stenodon.*

To resume.—The jaw of the Maestricht animal is three feet nine inches in length; the entire length of the skeleton is estimated at twenty-four feet; thus the head is nearly one-sixth of the total length—a proportion according with that of the crocodiles, but differing from the monitors. The tail is only ten feet long, and therefore but half that of the total length; while in the crocodile the tail exceeds the entire length of the body by one-seventh; its shortness is owing to the abbreviation of the bodies of the vertebræ.

This animal formed an intermediate link between the tribe of saurians without pterygoidal teeth, the monitors,—and those with them,—the iguanas: its only approach to the crocodiles was in a few partial characters, and in those general bonds of connexion which re-unite the entire family of oviparous quadrupeds. The bones of the extremities are but imperfectly known; those attributed to the Mosasaurus are said to indicate members adapted for natation rather than for progression on land, and to support the inference of M. Cuvier, that the original was a marine animal of great strength and activity, having a large vertically expanded tail, capable of being moved laterally with such force as to constitute a powerful instrument of progression, capable of stemming the most agitated waters.[1]

Teeth in every respect analogous to those of the Maestricht reptile were discovered by Dr. Harlan of Philadelphia, from the equivalent deposits of the cretaceous formation, the

[1] In the Memoir of M. Adrien Camper, "Sur quelques parties moins connues du squelette des Sauriens Fossiles de Maestricht," there are figures of several metacarpal or metatarsal bones from Maestricht, which the author describes as resembling those of the Crocodile, and probably belonging to the great saurian; among them is a small conical shaped bone, termed an ungual phalanx, but which has more the character of a dermal tubercle or spine; the figure, however, is too small and indefinite to show the true nature of the original.

ferruginous sands of New Jersey, in the United States. In 1830, my lamented friend, the late Dr. Morton of Philadelphia, (whose early death is so much to be deplored,) sent me specimens and casts of teeth of Mosasaurus, which agreed in every respect with those from the Netherlands; teeth of this kind are figured in Dr. Morton's "Synopsis of the Organic Remains of the United States:" Philadelphia, 1834. Of late years, vertebræ and other bones of the same genus have been found in these deposits; some of which, collected by Prof. Rogers, are figured and described in the Quarterly Journal of the Geological Society of London.

POLYPTYCHODON.—*Wall-case B.*—In a frame on the top of this Case there is a group of bones, some of which are nearly entire, others mere fragments, imbedded in plaster, and belonging to a large marine reptile; they are from the greensand strata near Hythe in Kent, and were collected and presented to the Museum by H. B. Mackeson, Esq. No part of the cranium or jaws has been discovered; but in the same deposits, as well as in the white chalk, very large conical longitudinally ridged teeth frequently occur; these have received the name of Polyptychodon. Prof. Owen, assuming that the teeth he has thus designated belong to the same species of reptile as the bones found in the same strata, has described the above isolated parts of the skeleton under the same name.

These consist of fragments of bones referred to the coracoid, ilium, ischium, and pubis; and portions of the humerus, part of a femur, tibia, and fibula, and several metatarsal bones. Of these, the thigh-bone, of which above two feet of the shaft remains, at once separates the reptile to which it belonged, from the Iguanodon and other gigantic saurians whose relics are occasionally found in the same formation, for it has no medullary cavity, its centre being occupied by a coarse cancellated structure, as in the cetaceans; this fragment is fifteen inches in circumference. The metatarsal bones are the most perfect of these remains; the longest was two feet in length, and four inches in transverse diameter in the middle.

Neither teeth nor vertebræ have been found, and the provisional name "Polyptychodon" simply indicates that the

large, conical, ridged teeth, and these detached bones, may probably appertain to the same genus or species of aquatic saurians.

In a subsequent section we shall enter upon the most interesting department of our present subject,—the history of those gigantic terrestrial saurians whose remains have been chiefly obtained from the strata of the south-east of England, and of which this division of the Gallery contains an interesting series.

LIGN. 45.—IGUANODON QUARRY, NEAR CUCKFIELD, SUSSEX. 1820.

1. Blue clay, forming the floor of the quarry.
2. Tilgate grit.
3. Soft sandstone.
4. Drift, or diluvium.

CHAPTER III.

PART IV.

GEOLOGY OF THE SOUTH-EAST OF ENGLAND.

"Ah, happy hills! ah, pleasing shade!
Ah, fields beloved in vain!
Where once my careless childhood stray'd,
A stranger yet to pain!
I feel the gales that from ye blow
A momentary bliss bestow."—GRAY.

QUARRY IN TILGATE FOREST—STRATA OF TILGATE FOREST—CHARACTER OF THE ORGANIC REMAINS—DISCOVERY OF THE FLUVIATILE ORIGIN OF THE STRATA—GEOLOGICAL STRUCTURE OF THE SOUTH-EAST OF ENGLAND—DRIFT OR DILUVIUM—TERTIARY OR EOCENE STRATA—CHALK FORMATION—WEALDEN FORMATION—ORDER OF SUPERPOSITION OF THE STRATA—PHYSICAL STRUCTURE OF THE COUNTRY—SECTION FROM LONDON TO THE SOUTHERN COAST—LONDON AND BRIGHTON RAILWAY SECTION—JOURNEY BY COACH FROM BRIGHTON TO LONDON—GEOLOGICAL MUTATIONS—FAUNA AND FLORA OF THE WEALDEN—SUMMARY.

QUARRY IN TILGATE FOREST.—From the motley crowds of strangers attracted to our overteeming metropolis by the "CRYSTAL PALACE and its wonders," thronging in countless numbers every place of public resort—the Gallery of Organic Remains of the British Museum not excepted,—I would transport the *Courteous Reader* for a brief space, and conduct him to the verdant hills and refreshing glades of my native county, and forgetting awhile "the noise, the hum, the din of men," visit the quarries, and examine the rocks and strata, whence the fossil remains of the colossal reptiles that will next engage our attention were exhumed.

In the good old times, when a well-appointed four-horse coach conveyed the traveller from Brighton to London in six or seven hours, the first resting stage for the passengers after leaving the Queen of Watering-places on a summer's morning, was the neat little town of Cuckfield in Sussex; whose single street straggles up the southern slope of a steep acclivity, formed by the anticlinal ridge of Wealden grit, which emerges from beneath the clays and sands of the adjacent valley of Cuckfield Park, near the seat of my friend, Warden Sergison, Esq.

On the summit of this ridge is "Whiteman's Green," and there, some thirty years since, was an extensive quarry, that had been occasionally worked for a quarter of a century, and was then in unwonted activity; the calciferous grit,—a hard calcareous sandstone formed by an infiltration of crystalline carbonate of lime into beds of sand,—which had always been in request for various economical purposes, having suddenly acquired increased value from the great demand for road materials, occasioned by the competition between the various boards of trustees, in consequence of the rapidly augmenting number of coaches and passengers, which the rising prosperity of Brighton had called forth.

From that quarry, long since filled up, and the area covered by pasturage and gardens, I collected the first and most interesting of the fossil remains of the Iguanodon, Hylæosaurus, Pelorosaurus, and other stupendons creatures whose existence was previously unknown and unsuspected.

The sketch, (*Lign.* 45,) represents the section exposed on one side of the quarry in 1820. The spire of Cuckfield Church is seen in the middle ground; the hills in the extreme distance are part of the range of South Downs to the west of Ditchling Beacon, an eminence of the chalk that rises to the height of 856 feet.

1. The lowermost bed, forming the floor of the quarry, is a stiff blue clay, in which bones and freshwater shells are occasionally met with.

2. The succeeding strata are composed of the fine calciferous grit or Tilgate-stone, which was extensively used as a road material, and occasionally for walls and buildings; but, owing to its extreme hardness, the difficulty of reducing it to blocks of convenient size, together with the adaptability

of the softer sandstone for the purpose, was but seldom employed in architecture. In some of the beds pebbles of quartz and jasper are so thickly interspersed, that the rock acquires the character of a conglomerate.

3. Above the Tilgate-grit are strata of fawn-coloured sands and sandstones, having the same lithological features as the cliffs at Hastings, and the rocks at Tunbridge Wells, Uckfield, &c. The upper part of these sandstones are in the state of laminated friable shales.

4. A thick bed of diluvial loam caps the whole, and forms the immediate subsoil of the surrounding country.[1]

STRATA OF TILGATE FOREST.—The quarry above described exhibits the usual character of the strata exposed in natural sections, and in the various stone-pits, and other artificial openings, in the surrounding country, and which extend, with but little variation, over the area of Tilgate and St. Leonard's Forests, to Horsham on the west, and along the Forest Ridge on the east. As a general term for these deposits was required for the convenience of description, I adopted that of "*Strata of Tilgate Forest*," on account of the proximity of the locality in which the saurian remains were first observed, to the district which, though now cultivated, and smiling with gardens and villas, still retains a name handed down from the earlier centuries, when it formed an integral part of the Roman *Sylva Anderida*, and in later times of the Saxon forest of *Andreadswald*.[2]

It was in this quarry, to which my attention was accidentally drawn by observing a fragment of bone in a block of stone by the road side, that I first obtained teeth, scales, and bones of reptiles and fishes, and fresh-water mollusks and crustaceans, and remains of terrestrial plants of a tropical character; a discovery which has invested this locality with a high degree of geological interest, since it was the first step in those researches which ultimately revealed the true nature and origin of the strata composing what is now termed the

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[1] Consult the "Fossils of Tilgate Forest," (published in 1827,) 1 vol., royal 4to. for details of the stratification, and figures of the principal fossils then obtained from the quarry: or, "Geology of the South-East of England," 1 vol. 8vo. 1833.

[2] See Horsfield's "History of the County of Sussex."

Wealden formation; a name happily suggested by my friend J. P. Martin, Esq. of Pulborough, to designate this remarkable series of fluviatile deposits.

Peculiar Character of the Organic Remains. — The most novel and extraordinary fossil remains which I obtained from the locality above described, and from other quarries around Horsham, Bolney, and Crawley, to which my researches extended, were the fragments of enormous mammalian-like bones, and the stems, branches, and foliage of terrestrial vegetables, and fluviatile mollusks; the univalves resembling the river-snails, or paludinæ, and the bivalves the fresh-water mussels or uniones. These phenomena were quite unexpected; for although, so far back as Woodward's time, the shells composing the limestones commonly known as the Sussex and Petworth marbles were supposed to be river-shells, yet that opinion had long been given up, and the whole series of strata forming the tract of country between the North and South Downs were regarded as unequivocally marine, and an integral part of the Cretaceous formation; the sands and sandstones being grouped together under the name of the *Iron Sand;* and several species of *ammonites, nautili,* and other deep-sea shells, were figured and described by Mr. Sowerby, and other eminent naturalists of that period, (1820,) as characteristic fossils of that group of deposits.

In that excellent work, Messrs. Conybeare and Phillips' "Outlines of the Geology of England and Wales," published in 1822, there is an admirable review of the geological relation of the "*Iron Sands*" below the chalk, according to the state of geological knowledge at that time, and which will be found in accordance with the account above given.[1]

Discovery of the fluviatile origin of the Strata.— For many years previously to my discovery of organic remains in the Wealden strata, I had diligently collected the fossils from the chalk, chalk-marl, galt, &c. around Lewes, where I then resided, and had acquired a tolerably extensive suite of the usual teeth, shells, corals, and other zoophytes of the

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[1] "Outlines of the Geology of England and Wales, by the Rev. W. D. Conybeare, and William Phillips, 1822," pp. 136—140. This volume appeared about three months before my first work on the Geology of Sussex, "The Fossils of the South Downs."

Cretaceous formation; these were arranged in separate drawers according to their respective localities. In the course of a few months after my first visit to the quarry at Cuckfield, I had obtained from the Weald, specimens of the rocks and organic remains in sufficient number to fill a cabinet of moderate size; and I soon became aware of the important difference between these fossils and the characteristic species from the chalk deposited in my other drawers: and by degrees the fluviatile origin of the strata spread over the Wealds of the South-East of England suggested itself to my mind.

The *absence* of ammonites, echinites, corals, terebratulæ, and other marine organisms, which constituted so large a proportion of my cretaceous collection, was the first striking anomaly that forced itself on my attention; and many a long and weary journey have I undertaken, to examine the materials thrown up from a newly-made well, or the section exposed by recent cuttings on the road-side, in the hope of obtaining data by which the problem might be solved; but it was many years ere the validity of my arguments received general assent. By reference to the various works on the Geology of the South-East of England[1] the reader interested in the history of the Wealden, may form some idea of the difficulties encountered, the mass of evidence required, and the prejudices of long cherished opinions to be overcome, and the able assistance and warm encouragement I received from my distinguished friend Sir Charles Lyell, and subsequently from other eminent British geologists, ere the fluviatile origin of the strata composing the Wealden was established.

As a considerable number of the organic remains that will come under our notice in Room V. of the Gallery of the British Museum, were obtained from the cretaceous and tertiary deposits of the South-East of England, it will be convenient to review the geological phenomena of the whole district in the present section of this work, which is in a great measure restricted to the consideration of the characters

[1] See "Wonders of Geology," 6th edit. lecture iv. p. 366, for a condensed exposition of the geology and fossil remains of the Wealds of Sussex, Kent, and Surrey. For the history of the character and relations of the strata below the chalk, consult the able Memoirs by Dr. Fitton in the "Geological Transactions."

and relations of the rocks and strata in which the most important fossils were discovered.

GEOLOGICAL STRUCTURE OF THE SOUTH-EAST OF ENGLAND.—The various strata that appear on the surface of the South-Eastern part of our island, constitute four natural groups or formations, namely, 1. The *Drift*, or *Diluvium;* 2. The *Eocene*, or *Tertiary strata;* 3. The *Chalk formation;* 4. The *Wealden.*

The Drift, or Diluvium.—These are the superficial accumulations which are irregularly spread over the surface, and form the immediate subsoil. They consist of layers of loam, clay, sand, gravel, and boulders, of variable extent and thickness, composed of waterworn materials which bear unequivocal evidence of having been drifted or transported from a distance by floods or inundations, or other agents of a like nature. Over considerable areas, as, for example, on both sides of the valley of the Thames, a fine silt or mud appears to have been deposited upon the drifted boulder-clay since the country had acquired its present physical configuration; and in this deposit, as well as in the ancient drift beneath, are found skeletons and detached bones and teeth of extinct species of Elephant, Rhinoceros, Hippopotamus, Elk, Ox, Horse, &c.; and, in some places, the remains of species still existing, are associated with those no longer known. Bones of carnivora, as the Hyæna, Bear, Tiger, Wolf, also occur in the drift, as well as in the ossiferous caves of which we shall treat when describing the contents of another department of the Museum.

The Tertiary or Eocene Strata of London.—The metropolis of England, like that of France, is built on the surface of a tertiary formation, consisting of beds of blue, yellow, and mottled clays, several hundred feet in thickness, with intercalations of loam, sand, gravel, &c. Some of the strata abound in extinct species and genera of marine shells, fishes, crustacea, &c.

The Chalk Formation.—The white calcareous rock of this formation is well known by the name of *Chalk;* but in the nomenclature of Geology, the term *Chalk Formation* comprises not only the pure limestone that extends over a considerable part of the country, but likewise subordinate strata of sand and sandstone, clays, marls, and limestones, very dissimilar in appearance and mineralogical character, but which present

such an accordance in the nature of the fossil remains imbedded in them, as to indicate that the entire series was accumulated while the same conditions of animal life prevailed. The organic remains of the chalk are essentially marine, and consist of many hundred species of shells, corals, radiariæ, &c. Numerous species and genera of fishes and crustaceans, and a few remains of reptiles, &c. obtained from the district under review, are deposited in the Gallery of the Museum. In some localities, drifted wood and fruits of terrestrial plants, and bones and teeth of reptiles, and other spoils of the land, have been discovered collocated with the usual marine productions, and these remains have evidently been carried down by rivers and streams into the sea, and transported by currents far from land, till they subsided in the depths of the ocean. One of the most remarkable instances of this kind is the portion of a skeleton of an Iguanodon discovered near Maidstone, in that division of the cretaceous greensand called the Kentish rag.

The Wealden.—An extensive series of clays, sands, and sandstones and shelly limestones, upwards of 1,000 feet in thickness, characterized by the terrestrial and fluviatile nature of the organic remains, and the almost entire absence of any relics of marine animals or plants.

Order of Superposition.—Such is the chronological sequence of the formations of the south-east of England; in other words, these several groups of marine and freshwater strata have been deposited in the following order, beginning with the lowermost or most ancient system:—

I. The Wealden: the delta of a river, composed of the alluvial debris of an extensive continent. These strata are spread over the uppermost beds of the Oolite, a vast oceanic formation, but which does not come within the scope of our present observations.[1]

II. The Chalk: the sediments of an ocean of great extent, deposited upon the Wealden.

III. The Tertiary or Eocene: accumulated in depressions on the surface of the Upper or White Chalk, consisting of marine, fluvio-marine, and lacustrine deposits.

With the view of simplifying the subject, the drift, or beds

[1] See "Geology of the Isle of Wight," p. 348.

of superficial transported materials, are omitted in the following commentary.

As each of these systems or formations is many hundred feet in thickness, it follows that the inferior strata would have been for ever concealed from observation, had the original order of superposition of the respective deposits remained undisturbed. But not only portions of each of the upper series, but even of the lowermost deposits, appear on the surface, and form an extensive tract of country, diversified by hills and valleys, and constituting one of the richest agricultural provinces of the British Isles. This distribution of the strata has originated from the displacements occasioned by those disturbing forces which have been in activity from the earliest periods of the present physical condition of the earth, and by which the beds of the ancient oceans and rivers have been elevated above the water, and converted into dry land. The nature of those changes we will now consider.

The Eocene deposits form the area on which London is situated, and extend over the surrounding country to a distance varying from ten to twenty or thirty miles. Around the margin of this series of strata the Chalk appears, and forms a distinct chain of hills on the south, west, and north; but on the east the range is broken by the valley through which the Thames winds its way to the sea. From this geological character of the metropolitan district, it results that all the lines of railway that proceed from London, traverse for the first ten or twenty miles beds of tertiary clay, loam, and loosely aggregated sand and gravel; hence the numerous slips that have taken place in the embankments at New Cross, Wandsworth, Hanwell, &c.; and in all these lines it is obvious from the nature of the soil and the steepness of the cuttings, that similar subsidences will again occur.

The next geological feature observable along the London railways is the *Chalk*, which is intersected by steep cuttings and tunnels; as for example in the South-eastern line, from Croydon to Merstham; and in the Great Western, from Maidenhead to beyond Wallingford. After passing through the Chalk, the lower subdivisions of the Cretaceous formation, viz. the *Marl*, *Firestone*, *Galt*, and *Greensand*, successively appear; and these are followed by the *Oolite* on the Great Western and Birmingham lines, and by the *Wealden* on the

South-eastern; but on the South-western the *Chalk* and the *Tertiary* strata only are exposed.

The *Chalk*, as is well known, constitutes the predominant geological feature of this part of England. The *Upper or White Chalk* rises into chains of hills called Downs, which are remarkable for their smooth and undulated outline, and form a well-defined geographical boundary. The southern range extends from Hampshire through Sussex to the sea-coast, terminating in the bold promontory of Beachy Head; the northern passes from Hampshire, through Surrey and Kent to the British Channel, and ends in the line of cliffs near Dover.

The lower Cretaceous strata compose ranges of hills less uniform in elevation and extent, which skirt the inner margin and escarpments of the Downs, and in some parts of Surrey and Western Sussex, attain an altitude equal to that of any portion of the North or South Downs. Leith Hill, in Surrey, is nearly 1,000 feet above the level of the sea.[1]

Physical Geography of the Country.—The Wealden deposits fill up the whole area between the North and South Downs, and are bounded on the west by the cretaceous strata of Hampshire, and on the east by the British Channel; they form the sea-coast from Pevensey in Sussex to Hythe in Kent.

Looking down upon the Wealden from any of the heights that command a view across the district, and of the distant boundary of chalk downs—as for example from Leith Hill, or from the summit of the escarpment of the North Downs, near Reigate—the observer might suppose that these fresh-water sediments occupy a depression or basin on the surface of the chalk, and that the strata of the North and South Downs extend under the whole of the deposits in the intervening area.

Geology of the South-East of England. — A slight examination of the natural sections of the respective strata where their relative position can be ascertained, is, however, sufficient to show the incorrectness of this hypothesis,

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[1] For details, *vide* a Memoir by the Author, "On the Geological Structure of the Country seen from Leith Hill," in the County History of Surrey; published by Mr. Ede of Dorking.

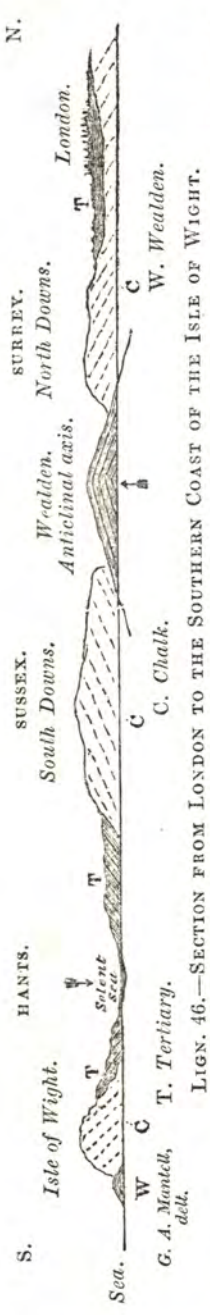
and to prove that the Wealden extends beneath the Chalk, both on the north and south, as shown in Lign. 47; and it is therefore certain that the Cretaceous strata were deposited upon the Wealden, and that they originally extended over the entire district between the North and South Downs, and were connected on the west with those of Hampshire and Wiltshire, and also occupied the area now covered by the British Channel; the chalk of the Isle of Wight being then continuous with the corresponding strata of the opposite coast of the Continent.

A careful examination of the phenomena under review, demonstrates that the removal of the chalk was not effected simply by denudation, but by a force acting from beneath, which broke up and elevated masses of the Tertiary, Cretaceous, and Wealden formations, in a line bearing a general direction from east to west; by this movement an anticlinal[1] position was given to the strata on each side the axis of greatest elevation. This axis is shown in the physical geography of the district by the chain of hills called the *Forest-Range*, that extends from the sea-coast at Hastings through the interior of the country by Crowborough Hill—an elevation of nearly 600 feet—to Loxwood, west of Horsham, where the Wealden disappears beneath the overlying greensand strata.

Section from London to the South-coast.—In all transverse sections of the district, *i. e.* from north to south, the strata on the north of the central line dip to the north-east, and those on the south to the south-west. There are, of course, many local variations in the inclination of the rocks, and numerous lesser anticlinal axes, or *saddles*, as they are provincially termed, and also longitudinal ridges and corresponding valleys, running parallel with the principal line of the disturbing force.

In consequence of this displacement of the strata, a section drawn from London through the North Downs, across the Wealden district, and through the South Downs, and carried on to the southern coast of the Isle of Wight, would present the arrangement shown in Lign. 46; in which are

[1] *Anticlinal*—a geological term, signifying inclined towards each other, like the ridge-tiles of the roof of a house.



LIGN. 46.—SECTION FROM LONDON TO THE SOUTHERN COAST OF THE ISLE OF WIGHT.

represented the *Tertiary* of the London basin resting on the chalk; the *Chalk* of the *North* Downs, dipping northwards; the anticlinal position of the *Wealden;* the *Chalk* of the *South* Downs, dipping southwards, with *Tertiary* strata on the southern flank: then the depression which forms the channel of the Solent sea; the *Tertiary* strata extending over the northern portion of the Isle of Wight; the *Chalk Downs* of the island, dipping northward; and, lastly, a small portion of the *Wealden*, emerging from beneath the chalk, on the south coast, at Brook and Sandown bays.

LONDON AND BRIGHTON RAILWAY SECTION.—A portion of this section is well displayed along the line of railway from London to Brighton. Leaving the station at London Bridge, the *Tertiary* clays with their characteristic fossils, are seen from beyond Deptford, by New Cross, Sydenham, &c.; and approaching Croydon, beds of gravel appear, with interspersions of olive-green sand. The valley beyond Croydon, along the side of which the railway proceeds, is a thick bed of gravel resting on the chalk.

Beyond the station called *Stoat's-nest*, is a fine section of the *Chalk with flint*, and the North Downs are perforated by a long tunnel carried through the solid rock, which emerges near Merstham, where the *firestone* and *chalk-marl* rise to the surface. The sands and clays of the greensand group are passed at the Red-hill and Godstone stations. The Wealden clays appear at Horley, and are succeeded by shales, limestones, sands, and sandstones, to the Crawley station.[1]

[1] The Horsham Railway, which branches off from the Brighton line, traverses the Wealden beds; and near that old quiet market-town of

Passing near Bletchingley, in Surrey, through a tunnel in the Wealden, we arrive at Balcombe, in Sussex, where laminated sandstones and shales are seen on each side the cutting. The general dip of the strata hitherto passed is to the *north-east;* but after crossing the deep Wealden valley beyond Balcombe, over a magnificent viaduct, the line runs along alternating layers of sands and clays, which dip to the *south-west;* we have therefore arrived on the southern side of the grand anticlinal axis of the Forest Ridge excavated by the tunnel through which we passed.

The Wealden strata continue with the same general inclination by Hayward's Heath,[1] which is traversed by a tunnel, to beyond St. John's Common, (formed of Weald clays and Sussex marble,) where they disappear beneath the lowermost greensand beds of the Chalk formation. The galt, firestone, and chalk-marl succeed; and, lastly, the white chalk of the South Downs, at Clayton Hill, through the base of which a long tunnel is carried, and emerges on the Downs on the south. The remainder of the line to the Brighton station, runs over, or through, hills and valleys of the white chalk.

Thus this railway passes through two ranges of chalk hills, viz. the North and South Downs, by tunnels; two of greensand, viz. near Red Hill in Surrey, and Hurstperpoint in Sussex; and two principal ridges of Wealden, viz. at Balcombe, and Hayward's Heath. There is not a railroad in the kingdom that in the distance of fifty miles exhibits geological phenomena of greater interest.

If we take a line bearing more to the west, as, for example, from London to the southern shore of the Isle of Wight, at Sandown Bay, we shall have the section represented in *Lign.* 46, which exhibits the entire series of the deposits, and their relative position.

JOURNEY FROM LONDON TO BRIGHTON BY COACH.—It may

Sussex, are Tower Hill quarry, Stammerham quarry, and other pits in which the Tilgate grits and sandstones are exposed, and where the characteristic fossils of the strata may be obtained of the workmen; with bones of the Iguanodon, Goniopholis, and other Saurians, stems of Clathraria, &c. See my "Geology of the S. E. of England," p. 212, or "Wonders of Geology," sixth edition, p. 372.

[1] Hayward's Heath station is within 1½ mile of Cuckfield, which lies to the right of the line.

interest the reader, who now can only catch a glimpse of the physical structure of this interesting district as he is whirled along by the railroad at the rate of thirty miles an hour, to learn the appearances presented to the outside passenger on the stage coaches that plied from Brighton to London at the period to which the introduction of this part of our little volume refers.

I had once the gratification of acting as cicerone to my friend, M. AGASSIZ, who has added to his high European reputation by his scientific labours in the new fields of research which his genius and perseverance have explored on the other side of the Atlantic; and leaving Brighton on the outside of "*The Age*," on a bright May morning, I described the geology of the district to the Swiss philosopher, who, though just returned from the sublime and majestic scenery of the Alps, was delighted with the lovely landscapes, and the interesting physical phenomena, of the Downs and Wealds of my native county, over which we travelled on our route to the metropolis.

The direct turnpike roads from London to Brighton pass over the entire series of tertiary and secondary strata of the South-East of England. Proceeding from the Thames, the traveller successively traverses the ancient silt that forms the present banks of the river, then a level tract of drift and diluvium, consisting of loam and gravel, in which remains of Elephants and other large terrestrial mammalians are occasionally found; and if he proceeds by the Reigate road, he goes through the beautiful suburban districts of Clapham, Tooting, &c. and passes over beds of gravel and clay, the ancient shores of the London basin.[1]

At Sutton he ascends the chalk hills of Surrey, and travels along an undulated tract, formed of the elevated masses of the chalk-ocean. Arriving at the precipitous southern escarpment of the North Downs, a magnificent landscape, displaying the physical geography of the Weald, and its varied and picturesque scenery, suddenly bursts on his view. At his feet lies the deep valley of *Galt*, in which Reigate is situated, and immediately beyond the town appears the elevated ridge

[1] See "Memoir on the Geology of Surrey," by the Author, in Brayley's History of the County, published by Mr. Ede, of Dorking.

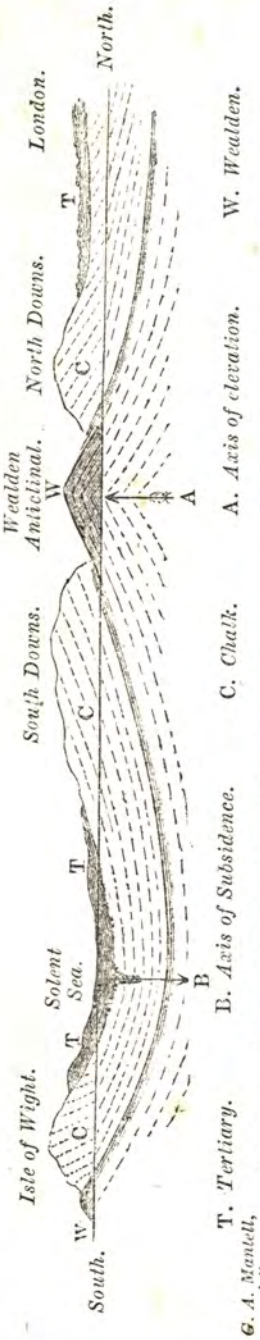
of *Greensand*, which, stretching westward, at Leith Hill rises to an elevation of a thousand feet; the highest point of land in the South-East of England. To the east, this division of the cretaceous deposits forms a chain of sand hills that stretches by Godstone in Sussex, and Sevenoaks in Kent, to the sea-shore near Folkstone and Hythe. The Forest Range of the Wealden occupies the middle region, extending westward to Horsham, and eastward to Crowborough Hill, its greatest altitude, and thence to Hastings, having on each flank the Wealden valleys of Kent and Sussex: while in the remote distance, the unbroken and gently undulated outline of the South Downs appears on the verge of the horizon.

Pursuing his journey, the traveller passes through the town of Reigate, along the valley of *Galt*, and over the ferruginous cretaceous sands of Cockshut Hill, and descending the steep escarpment, soon arrives at a marshy plain, where the abundance of rushes indicates the commencement of the argillaceous beds of the Wealden.

The *Weald-clay*, containing bands of shelly fresh-water limestone, appears at Horley Common; and while in the beginning of the journey the roads were seen to be repaired with chalk-flints, and near Reigate with cherty sandstone, or the iron-grit locally termed clinker, the materials now chiefly employed are the bluish grey shelly limestones of the Weald.

At Crawley, Wealden sands and sandstones appear, and the road is constructed of calciferous grit, and limestone containing bivalve shells, bones, portions of terrestrial plants, &c. Traversing Tilgate Forest and Handcross, over a succession of gentle anticlinal ridges of sandstone, and across clay valleys, he rapidly descends from the sandstone ridge of Bolney, to Cuckfield, leaving on the right the site of our Iguanodon quarry, near which a windmill now stands, and again journeys along a district of Weald-clay with fresh-water limestones.

Ferruginous greensand like that of Reigate reappears at Hickstead, and is succeeded by a tract of Galt and Chalk-marl; and finally the road, entering a defile in the South Downs, passes on to Brighton; the traveller having in the course of his journey crossed from one system of chalk hills to another; that is, *over* the North Downs of Surrey, and the South Downs of Sussex, (*through* which he passed by



T. *Tertiary.* B. *Axis of Subsidence.* C. *Chalk.* A. *Axis of elevation.* W. *Wealden.*

G. A. Mantell, *del.*

LIGN. 47. IDEAL SECTION FROM LONDON TO THE SOUTHERN COAST OF THE ISLE OF WIGHT.

tunnel on the railroad,) and across the intervening region composed of the sediments of a delta of incalculable antiquity.[1]

GEOLOGICAL MUTATIONS.—The present distribution of the strata, as shown by the preceding observations, appears to admit of the following explanation. Assuming the original deposition of the strata to have been horizontal, and in the sequence above pointed out, the Wealden resting on the Oolite, the Chalk on the Wealden, and the Tertiary on the Chalk—the whole surface of the country must have originally consisted of the same Tertiary strata as those of London and its vicinity. If by a force acting from beneath, in the direction of the arrow, A, *Lign.* 47, the entire series were broken through, the chalk with the superincumbent tertiary strata would be thrown into highly inclined positions towards the north and south; and if a similar disturbance took place along the area occupied by the British Channel, England would be separated from the Continent, and the small portion, now the Isle of Wight, be forced into its present position, by a subsidence in the direction of the arrow, B, *Lign.* 47, along the course of the present bed of the Solent Sea. The actual position of the strata, could our observations extend to a sufficient depth, would probably present the section sketched in *Lign.* 47, which is in accordance with the local phenomena observable in the Isle of Wight, and other places introduced in the diagram.

[1] See Geological Excursion in "Medals of Creation," vol. ii. p. 908.

It is obvious, were the Forest Range of the county of Sussex swept away by the encroachments of the sea, and the area it occupied buried beneath the waves, the North Downs would present a strict correspondence in geological structure with the Isle of Wight; for a portion of the Wealden would appear on the south shore at the base of the chalk escarpment, and be succeeded on the north by the greensand, galt, firestone, marl, and white chalk; and the latter surmounted by tertiary deposits.[1]

FAUNA AND FLORA OF THE WEALDEN.—The most important organic remains of the animal kingdom imbedded in the Wealden strata are, unquestionably, in a physiological point of view, the teeth and bones of the colossal terrestrial reptiles, which in their osteological characters approach nearer to the mammalian type than any of the existing species of oviparous quadrupeds. But as these are the relics of land animals transported from a distance and imbedded in the sediments brought down by the waters, they yield but little aid to the geological inquirer in his attempts to determine the origin and formation of the rocks and strata. The vestiges of the beings which inhabited the waters by which the sediments were deposited, can alone afford information as to the physical conditions which then prevailed. Hence, the durable remains of zoophytes, echinoderms, mollusks, crustaceans, fishes, and aquatic reptiles, are the objects to which the geologist more particularly directs his attention; and shells, from their durability, and the indications they afford as to the structure and economy of the animals that inhabited them, are sought for with avidity.

I have already mentioned how much the absence of marine shells and corals in the Wealden contributed to awaken my

[1] For fuller information on the subjects embraced in this sketch, see "Elements of Geology," by SIR CHARLES LYELL; and the "Geology of the South-East of England," or the "Wonders of Geology," by the Author; or "Geological Excursions round the Isle of Wight," &c. 2d. edit., 1851.

On the elevation of the Wealden, and the consequent changes in the relative level of the sea and land, consult the masterly paper of MR. HOPKINS, *President of the Geological Society*, "On the Geological Structure of the Wealden District and of the Bas Boulonnais," ("Geol. Trans." vol. vii.); and Mr. J. P. MARTIN'S beautiful volume, "On the Geological Phenomena of Western Sussex," Pulborough, 1 vol. 4to, with Maps and Sections.

mind to the fluviatile nature of those deposits, and assisted in establishing the fresh-water origin of the entire series now comprised in that formation.

The shells of the Wealden, as might be anticipated from the character of the molluscous fauna of the rivers and lakes of the present time, though occurring in immense numbers in some of the beds, comprise but an inconsiderable number of genera; and these, with but few exceptions, are fluviatile, or lacustrine forms: no traces of land mollusks have, I believe, been observed.

The species hitherto met with in this country belong to the genera Paludina, Limnea, Physa, Planorbis, Paludina, Melania, and Cyclas, Cyrena, Psammobia, Unio, Mytilus, &c.; brackish water and marine shells occasionally occur in some of the lower deposits; and in the Purbeck series there is a bed of oyster shells. The most remarkable fact relating to the fresh-water mollusca is the discovery by that eminent naturalist Prof. Edward Forbes, in the Purbeck strata, of shells, of the genera *Physa*, *Planorbis*, and *Limnea*, that closely resemble the existing species inhabiting our pools and rivers.

In my first published account of the fossils of Tilgate Forest, a few species of paludina, and of unio and cyclas and cyrena, comprised all the mollusks then known. The Sussex or Petworth shelly limestone, some layers of which take a good polish, and are, therefore, called marble, is a mass of paludinæ of two or three species, with innumerable cases or shells of the fresh-water entomostracous crustaceans, Cypris and Estheria; and some of the bands of limestone almost wholly consist of a small species of unio.

Some of the beds of clay abound in potamides and melaniæ, and others are made up of the shells of the fresh-water bivalves cyrena and cyclas. The most remarkable and interesting of these fluviatile mollusks, are the large mussels (*Unio Valdensis*) first discovered by me in the Isle of Wight, and which equal in size, and closely resemble in form, some existing species that inhabit the Ohio and Mississippi.[1]

Insects.—A few legs and elytra of Insects have been found in the Wealden of Kent, and a considerable number of

[1] See "Geological Excursions round the Isle of Wight." Pl. VI.

species and genera of coleoptera, neuroptera, &c. in the outlying beds in Buckinghamshire, and in the Vale of Wardour, in Wiltshire.[1]

Fishes.—The fossils of this class comprise but a few genera. The most common belong to two species of a large ganoid fish, the *Lepidotus,* which is closely allied to the existing *Lepidosteus* or Bony Gar of the American rivers. The scales and teeth of these fishes are very abundant; there are some fine examples of the cranium, body and fins, in Room V. Teeth and scales, and the dorsal ray or spine of the genus *Hybodus,* belonging to the shark family, are also very common. Teeth of *Gyrodus, Pycnodus* and *Sphærodus* are also met with; and I have lately collected from the strata of Tilgate Forest, remains of a species of *Belonostomus,* a genus previously only known in the chalk near Lewes.[2]

Of corals and other zoophytes I have not detected the least vestige in any of the Wealden strata. Echinoderms are also absent; but Prof. E. Forbes has discovered one species in the Purbeck beds.

Flora of the Wealden.—The most characteristic vegetable remains are the Clathraria Lyelli, Endogenites erosa, Dracæna Benstedi, Equisetum Lyelli, Lonchopteris and Sphenopteris Mantelli, of which there are specimens in the Wall-cases of Room I. (*ante,* pp. 27, 32, 45, 48).

In a few localities (Sandown Bay and Brook Point, in the Isle of Wight,) stems of coniferous trees occur in such numbers, and under such conditions, as to show that the accumulations are attributable to rafts of forest-trees that were swept down by the flood of a great river, and deposited where they are now found in a fossil state.[3] In another remarkable locality, the Isle of Portland, the trees are petrified on the soil, and in the position in which they grew (*ante,* p. 56).

I have lately obtained numerous cones or strobiles of fir-trees belonging to two distinct species, perhaps genera.[4] Seeds of the common fresh-water plant, the *Chara,* have been

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[1] See the Rev. J. Brodie's beautiful work on Fossil Insects.

[2] See Catalogue of the Mantellian Museum of the Royal Sussex Scientific Institution.

[3] For an account of the fossil raft of coniferous trees at Brook Point, see "Geological Excursions round the Isle of Wight," p. 277.

[4] Ibid. second edition, p. 452.

found in the Purbeck beds.[1] Such are the general features of the fauna and flora of the Wealden epoch, according to the present state of our knowledge.

GEOLOGICAL SUMMARY.—From this survey of the South-East of England, we learn that the present configuration of the surface has resulted from a succession of physical changes which took place in periods incalculably remote, and long antecedent to the creation of the human race; and that the country is composed of sediments deposited by ancient seas, rivers, and lakes, whose waters teemed with myriads of beings of extinct genera and species, and of the spoils of countries which enjoyed a much higher temperature than any part of modern Europe, and were clothed with palms, tree-ferns, cycadeous plants, and pine-forests, and inhabited by gigantic reptiles, whose races have long since been swept from the face of the earth.

The phenomena we have passed in review may be referred to four principal epochs; but the period of time over which each extended, cannot be conjectured with any approach to probability.

I. *The Wealden Epoch.*—This, which is the most ancient era comprehended in the present survey, comprises the period during which the strata, that in the south-east of England emerge from beneath the chalk, and occupy the area between the north and south boundaries of that formation, were deposited. The total thickness of these deposits cannot be accurately determined, but amounts to upwards of 1,000 feet. The innumerable layers of mollusks and crustaceans, and the prodigious accumulation of the bones of reptiles and fishes, and of the trunks, branches, and foliage of vegetables, the whole consisting of materials brought down by rivers and floods of fresh water, and slowly deposited in bays, deltas, or estuaries, afford unquestionable evidence of the immense period of time during which the Wealden was in the progress of formation.

II. *The Cretaceous Epoch.*—The next geological cycle embraces the deposition of that extensive series of strata, whose organic contents demonstrate that they were accumulated in an ocean of vast extent, and which, probably, like the

[1] "Geological Excursions round the Isle of Wight," pp. 109, 463.

Atlantic, embraced both continents; for cretaceous deposits are spread over a considerable part of North America, as well as Europe. The subsidence of the Wealden must necessarily have taken place before the lowermost of the chalk-strata (the neocomian) were deposited; but the destruction of the islands, or continents, from whose spoils the Wealden deposits were derived, must have been gradual, since remains of their fauna and flora are found sparingly distributed in the cretaceous sands.

It is obvious, that the period through which the chalk-ocean extended, with but little modification in its character—for the organic remains of the formation maintain a very general correspondence throughout—must have been of great duration, however rapid may have been the reproduction of those infinitesimal animal forms (the *Foraminifera*) of which the strata of white limestones are so largely composed.

III. *Tertiary Epoch.*—The close of the cretaceous era appears to have been followed by elevatory movements, which broke up the bed of the ocean, and slowly upheaved large areas; and as the elevation continued, the deposits which had been formed in the profound depths of the sea were brought to the surface, and became exposed to the destructive action of the waves.

These masses of cretaceous rocks were gradually disintegrated and swept away, and in some places the Wealden beds gradually emerged above the waters, and, finally, the petrified forest of Portland rose in the midst of the sea, and became dry land. At length some portions of the strata attained an elevation of several hundred feet, and a group of islands was formed; but in the depressions or basins of the chalk still covered by the waters, sediments derived from the destruction of the sea-cliffs, and the degradation of the surface of the land, were slowly deposited.

Herbivorous and carnivorous mammalia of numerous genera and species now, for the first time, appeared, and inhabited the islands and continents formed by the elevated masses of the former ocean-bed; and in the new (tertiary) deposits then in progress, the bones of the animals, and the remains of the trees and plants, became imbedded.

IV. *Post-tertiary Epoch.*—The Tertiary epoch in its turn also passed away—the elevatory movements continued—other

masses of the bed of the chalk-ocean, and of the Wealden strata beneath, became dry land—and at length those more recent deposits, containing the remains of the herbivorous mammalia which were the last tenants of the country. The oak, elm, ash, and other trees of modern Europe, now sprang up where the groves of palms and tree-ferns once flourished—the stag, boar, and horse, ranged over the plains in which were entombed the bones of the colossal reptiles—and finally, *Man* appeared, and took possession of the soil.

Subsequently to the occupation of these islands by the aboriginal tribes, the country has undergone no important physical mutations. The usual effects of the atmosphere, the wasting of the shores by the encroachments of the sea, the erosion of the land by streams and rivers, the silting up of valleys, and the formation of deltas, are apparently the only terrestrial changes to which the south-east of England has been subjected during the historic ages.

At the present time, the deposits containing the remains of the mammoth and other extinct mammalia, are the sites of towns and villages, and support busy communities of the human race ; the Hunstman courses, and the Shepherd tends his flocks on the elevated masses of the bottom of the ancient chalk-ocean—the Farmer reaps his harvests from the cultivated soil of the delta of the country of the Iguanodon—and the Architect obtains from beneath the petrified forest the materials with which to construct his temples and his palaces : while, from these various strata, the Geologist gathers together the relics of the beings that lived and died in periods of unfathomable antiquity, and of which the very types have long since been obliterated from the face of the earth, and endeavours from these memorials, to trace the nature and succession of those physical revolutions which preceded all history and tradition.[1]

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[1] "Wonders of Geology," p. 446.

CHAPTER III.

PART V.

THE IGUANODON.

DINOSAURIAN REPTILES—IGUANODON—DISCOVERY OF THE TEETH OF THE IGUANODON—THE IGUANA—LOWER JAW OF REPTILES—CHARACTER OF THE TEETH OF THE IGUANODON—LOWER JAW OF THE IGUANODON—TYMPANIC BONE—VERTEBRÆ—RIBS—CLAVICLE—CORACOID—SCAPULA—STERNUM—PELVIS—SACRUM—ILIUM—ISCHIUM—PUBIS—FEMUR—TIBIA—FIBULA—TARSALS—METATARSALS AND PHALANGEALS—UNGUEALS—HUMERUS—METACARPALS AND PHALANGEALS—DERMAL BONES—QUARRY NEAR MAIDSTONE—MAIDSTONE IGUANODON—PHYSIOLOGICAL INFERENCES—CONCLUDING REMARKS.

DINOSAURIAN REPTILES.—We return from our geological excursion to the Wealds of Sussex, and the quarries of Tilgate Forest, whence the greater part of the fossil remains we have next to examine were collected, and resume our review of the contents of the wall-cases in Room III.; some of which engaged our attention in the previous divisions of this chapter.

The gigantic extinct reptiles included in the genera Megalosaurus, Iguanodon, Hylæosaurus, and Pelorosaurus, differ so essentially in their organization from all other oviparous quadrupeds, as to constitute a distinct tribe or order, to which the name *Dinosaurian* has been assigned by Professor Owen—a term expressive of the stupendous magnitude and extraordinary structure of these remarkable saurians.

The characters of this order are defined as follows:—

"This group, which includes at least *three*[1] well established genera, is characterized by a large sacrum, composed

[1] It will be seen in the sequel that there are *five*, if not six, genera of Wealden reptiles, with a similar construction of the sacrum.

of *five*[1] vertebræ of unusual construction; by the height, breadth, and outward sculpture of the neural arch of the dorsal vertebræ; by the two-fold articulation of the ribs to the vertebræ, viz. at the anterior part of the spine by a head and tubercle, and along the rest of the trunk by a tubercle attached to the transverse process only; by broad, and sometimes complicated, coracoids, and long and slender clavicles, whereby Crocodilian characters of the vertebral column are combined with a Lacertian type of the pectoral arch. The dental organs also exhibit the same transitional or connecting characters, in a greater or lesser degree. The bones of the extremities are of large proportional size for saurians; they have large medullary cavities, and with well developed and unusual processes, and are terminated by metacarpal, metatarsal, and phalangeal bones, which, with the exception of the ungual phalanges, more or less resemble those of the heavy pachydermal mammalia, and attest, with the hollow long-bones, the *terrestrial* habits of the species.

"The combinations of such characters—some, as the sacral ones, altogether peculiar among Reptiles—others borrowed, as it were, from groups now distinct from each other—and all manifested by creatures far surpassing in size the largest of existing reptiles, will, it is presumed, be deemed sufficient ground for establishing a distinct tribe, or sub-order, of Saurian Reptiles.

"Of this tribe, the principal and best established genera are the *Megalosaurus*, the *Hylæosaurus*, and the *Iguanodon*; the gigantic *Crocodile-lizards of the dry land*; whose peculiarities of osteological structure distinguish them as clearly from the living terrestrial and amphibious Saurians, as the opposite modifications for an aquatic life characterise the extinct *Enaliosaurians*, or marine lizards."[2]

The remains of these animals are chiefly found in the Wealden deposits; but of the first-mentioned genus, the Megalosaurus, the most important parts of the skeleton have been obtained from the lower oolitic strata at Stonesfield, near Oxford; and of the Iguanodon, a highly interesting specimen has been discovered in the greensand of the Chalk formation, near Maidstone.

[1] The sacrum of the Iguanodon is composed of six vertebræ.

[2] "British Assoc. Report on Fossil Reptiles," 1841, p. 144.

These genera include the colossal crocodile-lizards of the dry land of the secondary geological epochs. The most remarkable peculiarity in the skeleton is the construction of the sacrum, for, while in all other reptiles this key-stone of the pelvis consists of but two united vertebræ, in the Dinosaurians it is composed of five or six anchylosed vertebræ, the neural arches of which are shifted to the interspaces between the bodies of those bones, and thus great solidity and strength are imparted to the pelvic arch.

From the enormous size of the bones of these animals, their remains have excited the curiosity even of the common observer; and although an exaggerated idea has been generally entertained of the magnitude of the originals, yet when reduced to their natural proportions by the rigorous formula of the anatomist, their dimensions are sufficiently stupendous to satisfy the most enthusiastic lover of the marvellous.[1]

The present section will be devoted to the consideration of the structure and physiology of the colossal reptile whose relics occupy nearly the whole of Wall-case *C*, and which is, perhaps, the most extraordinary, both in regard to its history and organization, of the saurians included in the Dinosaurian order—the IGUANODON.

IGUANODON.—The remains of this stupendous reptile that have been collected since my first discovery of a tooth in

[1] It is twenty-five years since the publication of my "*Fossils of Tilgate Forest*," in which are numerous figures of bones of the Wealden reptiles, previously altogether unknown. Of this work, although eulogized by the illustrious CUVIER, with that kind and generous bearing towards every cultivator of Palæontology, for which he was as much distinguished as for his surpassing genius, not fifty copies were sold. At that time there was not an articulated skeleton of a crocodile in the Hunterian Museum, and but very few skeletons of any other reptiles, to which access could be had for comparison with the fossil bones; and many of the latter were repeatedly taken by me to the College of Surgeons without obtaining any clue, even as to the place they held in the skeleton.

But now the comparative anatomist may enjoy the privilege of inspecting, at his ease, the immense collections of fossil reptiles in the British and other Museums, and with all the advantages which access to the first anatomical Museum in the world, the Hunterian, presents for the comparison of fossil with recent structures. It is, therefore, greatly to be deplored, that a spirit of self-aggrandizement and jealousy has exerted its baneful influence over this department of palæontology; and in consequence, there is not one young British anatomist who pursues fossil Erpetology as a special branch of study.

the quarry near Cuckfield, are very numerous, and comprise a considerable portion of the skeleton; but no part of the cranium has yet been recognised.

The specimens in the British Museum, all of which were originally in my collection, and were developed with my own hands, comprise the following: viz.—teeth, portions of the upper and lower jaws, tympanic bone; cervical, dorsal, lumbar, and caudal vertebræ, with their apophyses; the elements of the pectoral arch,—namely, clavicle, coracoid, scapulæ; fragment of the sternum, ribs; sacrum, iliac bones, ischium (?), pubis (?); femur, tibia, fibula, metatarsals and phalangeals; humerus, metacarpals, phalangeals, unguals; and dermal spines or tubercles.

I propose to describe these several parts of the skeleton in the order in which they are here enumerated, and afterwards consider the physiological inferences suggested by their examination.

To facilitate reference to the various objects that will be brought under our notice, the following diagram is appended:—

BONES OF REPTILES FROM THE STRATA OF TILGATE FOREST, IN SUSSEX.

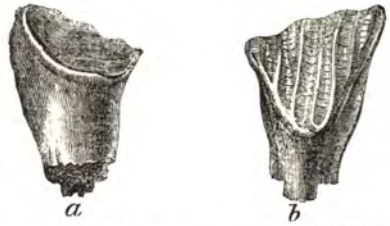
WALL-CASE C. [3.]

Top of the Case. [Polyptychodon from Hythe (p. 200.)]

Upper Shelf.	Coracoid-bones and Scapulæ.	Portion of a femur, figured in "Fossils of Tilgate Forest," Pl. XVIII.	Femur, tibia, fibula, and two metatarsals of the same reptile.	Portion of os-pubis, ischium, ilium, and other bones.	
Middle-Compartment.	Tibia and fibula belonging to the same Iguanodon as the femur, (2.)	Remarkably fine Femur. (3.)	The largest and most perfect femur; from Loxwood. (1.)	Remains of four Sacral-bones. 1. 2. 3. 4.	Femur. (5.) Inferior part of the femur belonging to the tibia and fibula. (2.)
Narrow front ledge.	Numerous teeth of Iguanodons, &c. Portion of the lower jaw of *Regnosaurus Northamptoni*; and of the upper jaw of Iguanodon. A femur of a very young Iguanodon. Horn, or dermal tubercle of the Iguanodon. Polished sections of a tibia, &c.				
Lowermost Compartment.	Various vertebræ.		Slab of Tilgate-stone, with six very fine Caudal vertebræ of the Iguanodon, and three chevron-bones.	Metatarsals, metacarpals, and phalangeals.	
	Chevron-bones.	Vertebræ of the Pelorosaurus.		Humerus of the Iguanodon.	Metatarsal bones, &c.
	Vertebræ, chevron-bones, &c.			Very fine Rib, 40 inches long.	Tympanic bones.
	Various bones.	Clavicles.	Portions of Ribs of Iguanodon, &c.	Ribs.	Vertebræ.

DISCOVERY OF THE IGUANODON.—Soon after my first discovery of bones of colossal reptiles in the strata of Tilgate Forest, some teeth of a very remarkable character particularly excited my curiosity, for they were wholly unlike any that had previously come under my observation; even the quarrymen accustomed to collect the remains of fishes, shells, and other objects imbedded in the rocks, had not observed fossils of this kind; and until shown some specimens which I had extracted from a block of stone, were not aware of the presence of such teeth in the stone they were constantly breaking up for the roads.

The first specimen that arrested my attention was a large tooth, which from the worn, smooth, and oblique surface, of the crown, had evidently belonged to an herbivorous animal; and so entirely resembled in form the corresponding part of an incisor of a large pachyderm ground down by use, that I was much embarrassed to account for its presence in such ancient strata; in which, according to all geological experience, no fossil remains of mammalia would ever be discovered; and as no known existing reptiles are capable of masticating their food, I could not venture to assign the tooth in question to a saurian.



LIGN. 48.—TOOTH OF THE IGUANODON. ($\frac{2}{3}$ *nat. size.*)
The crown worn down below the lateral denticulations.
a. Posterior aspect.
b. Anterior aspect.

As my friend Mr. (now Sir Charles) Lyell was about to visit Paris, I availed myself of the opportunity of submitting it to the examination of Baron Cuvier, with whom I had the high privilege of corresponding: and, to my astonishment, learned from my friend, that M. Cuvier, without hesitation, pronounced it to be an upper incisor of a Rhinoceros.[1]

[1] It is delightful to quote the following generous admission of this mistake recorded by the illustrious Cuvier himself in his immortal work. "Des fragmens d'os du métacarpe ou du métatarse sont si gros qu'un premier coup-d'œil je les avoir pris pour ceux d'un grand hippopotame." "Avec ces os M. Mantell en a trouvé de crocodile, de tortue, de plésiosaurus, de cétacés, et d'oiseaux, et il en a recueilli aussi dont il n'est pas possible d'assigner le genre. On ne peut trop l'encourager dans le pro-

I had previously taken this tooth, and some other specimens, to a meeting of the Geological Society in London, and showed them to Dr. Buckland, Mr. Conybeare, Mr. Clift, and other eminent men who were present, but without any satisfactory result; in fact I was discouraged by the remark, that the teeth were of no particular interest, as there could be little doubt they belonged either to some large fish allied to the *Anarhicas lupus*, or wolf-fish, the crowns of whose incisors are of a prismatic form, or were mammalian teeth obtained from a diluvial deposit. Dr. Wollaston alone supported my opinion that I had discovered the teeth of an unknown herbivorous reptile, and encouraged me to continue my researches.[1]

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jet qu'il a de donner bientôt au public une description détaillée et des figures de ces trésors géologiques.

"La première place pour la singularité y appartiendra, sans doute, à des dents (Pl. XXI. fig. 28, 32), dont il a bien voulu me communiquer quelques-unes, et dont je ne puis m'empêcher de dire ici quelques mots, d'autant que si elles peuvent venir d'un poisson, comme on le soupçonne, il n'est pas impossible qu'elles provienneut aussi d'un saurien; mais d'un saurien encore plus extraordinaire que tous ceux dont nous avons connaissance.

"Ce qui leur donne un caractère unique, c'est d'user leur pointe et leur fust transversalement, comme les quadrupèdes herbivores, et tellement, que la première qui me fut présentée s'étant trouvée dans cet état de détrition, je ne doutai nullement qu'elle ne vînt d'un mammifère; il me sembloit même quelle ressembloit beaucoup à *une mâchelière de rhinocéros*, ce qui vu son gisement, auroit dérangé toutes mes idées sur les rapports des os avec les conches, au moins, autant qu'auroit pu le faire le petit carnassier de Stonesfield: *ce n'est que depuis que M. Mantell m'en a envoyé une série d'entières et de plus ou moins usées, que je me suis entièrement convaincu de mon erreur.*"—*Recherches sur les Ossemens Fossiles*, tome v. pp. 350, 351.

[1] "The genuine worker and searcher after truth may conceive the feelings with which I find myself misrepresented," * and my labours and discoveries disparaged in the Palæontographical Society's publication, and will, therefore, not impute to egotism the insertion of extracts corroborative of the accuracy of my narrative, though the passages cited may be too eulogistic.—"And here I may notice, when speaking of the Iguanodon, that there is a peculiar appropriateness in your awarding the Wollaston Medal to the discoverer of that genus, since I well remember the evening at the Geological Society, when Dr. Wollaston, having seen the first teeth exhibited by my friend in London, warmly encouraged him to pursue his researches, and that, too, when Mr. Mantell thought others were less struck and less interested than the subject deserved."—*Anniversary Speech of the President* (Mr. Lyell) *of the Geological Society, Feb.* 20, 1835. See Appendix E.

* Quoted from Prof. Owen's "Monograph on Cretaceous Reptiles." See the same "Monograph," for a practical illustration of these remarks.

And, as if to add to the difficulty of solving the enigma, some metacarpal bones which I soon after discovered in the same quarry, and forwarded to Paris, were declared to belong to a species of Hippopotamus.[1] Subsequently a dermal horn or tubercle from the same stratum, was declared by competent authorities to be the lesser horn of a Rhinoceros; and Dr. Buckland, with the generous kindness which marked his character, wrote to guard me against venturing to publish that these teeth, bones, and horn, were found in the "Iron-sand formation," with which the Tilgate beds were then classed, as there could be no doubt they belonged to the superficial diluvium: and as the upper beds of the conglomerate in which these first specimens were found, was only covered by loam and vegetable earth, there was no clear stratigraphical evidence to support a contrary opinion. Other specimens, however, were soon procured by stimulating the diligent search of the workmen by suitable rewards, and at length teeth were obtained which displayed the serrated edges, the longitudinal ridges, and the entire form of the unused crown. I then forwarded specimens and drawings to Baron Cuvier, and repaired to London, and with the aid of that excellent man, the late Mr. Clift, ransacked all the drawers in the Hunterian Museum that contained jaws and teeth of reptiles, but without finding any that threw light on the subject. Fortunately, Mr. Samuel Stuchbury, then a young man, was present, and proposed to show me the skeleton of an Iguana which he had prepared from a specimen that had long been immersed in spirits; and, to my great delight, I found that the minute teeth of that reptile bore a closer resemblance in their general form to the fossils from Tilgate Forest,[2] than any others with which I was able to institute a comparison.

It was not, however, until I had collected a series of

[1] See the previous note.

[2] A letter from my excellent friend the late Wm. Clift, Esq. is now before me, (it is dated Oct. 26, 1824,) enclosing the beautiful drawing of the upper jaw and teeth of this Iguana, which is lithographed in my "Fossils of Tilgate Forest." He states, "If you have occasion, or think it necessary, to mention the specimen of which you wished me to make a sketch, it is only fair to remind you that it was prepared by Mr. Samuel Stuchbury, and that, although he intends to present it to the Hunterian Museum, it does not at present belong to it. Mr. Stuchbury informs me that the present individual is the common edible Iguana of the West-India Islands; but he is no further acquainted with its species or history."

specimens, exhibiting teeth in various states of maturity and detrition, that the correctness of my opinion was admitted, either as to the character of these dental organs, or the geological position of the rocks in which they were imbedded.

In the meanwhile I continued my researches, and obtained additional teeth, which, together with drawings of the most illustrative specimens in my collection, were transmitted to Baron Cuvier, who favoured me with the following observations on the subject:—

"J'ai attendu pour vous en donner avis que j'aie eu le tems de les examiner. Aujourd'hui que je viens de le faire, je m'empresse de vous temoigner ma reconnaissance, et de vous communiquer quelques idées que m'ont fait naître l'examen des curieuses dents qui font partie de votre envoi, ainsi que celui de la planche du Mémoire que vous allez publier à leur égard.

"Ces dents me sont certainement inconnues: elles ne sont point d'un animal carnassier, et cependant je crois qu'elles appartiennent, vu leur peu de complication, leur dentelure sur les bords, et la conche mince d'émail qui les revêt, à l'ordre des reptiles. A l'apparence extérieure on pourrait aussi les prendre pour des dents de poissons analogues aux tetrodons ou aux diodons; mais leur structure intérieure est fort différente de celles-là. N'aurions-nous pas ici un animal nouveau, un reptile herbivore? et de même qu'actuellement chez les mammifères terrestres, c'est parmi les herbivores que l'on trouve les espèces à plus grande taille, de même aussi chez les reptiles d'autrefois, alors qu'ils étaient les seuls animaux terrestres, les plus grande d'entr'eux ne se seraient-ils point nourris de végétaux? Une partie des grands os que vous possédez appartiendrait à cet animal, unique jusqu'à présent dans son genre. Le tems confirmera ou infirmera cette idée, jusqu'il est impossible qu'on ne trouve pas un jour une partie du squelette réunie à des portions de mâchoires portant des dents. C'est ce dernier objet surtout qu'il s'agit de rechercher avec le plus de persévérance. Si vous pouviez obtenir de ces dents adhérentes encore à une portion un peu considérable de mâchoire, je crois que l'on pourrait résoudre le problème. J'ai pris la liberté de parler de quelques-uns de ces objets dans le volume que je fais imprimer en ce moment, et j'y ai exprimé toute la reconnaissance que vous doivent les naturalistes. Si par de nouvelles observations vous verriez à découvrir de nouveaux faits capables d'éclairer ces questions, vous me rendriez un très grand service de vouloir bien continuer à m'en donner communication. — *Paris*, 20 *Juin*, 1824."

These remarks of Baron Cuvier were the only hints that I received from any of my scientific friends or correspondents, as to the character and probable relations of the animal to which the recently discovered teeth belonged; and as my

arduous professional duties in a provincial town remote from museums and libraries of natural history, forbade the hope of speedily acquiring more satisfactory information, I transmitted to the Royal Society, through my friend Davies Gilbert, Esq., figures and descriptions of the most illustrative specimens, adopting (at the suggestion of the Rev. W. D. Conybeare) the name of *Iguanodon* for the extinct reptile, to indicate the resemblance between the fossil teeth and those of the recent Iguana, which Mr. Stuchbury's specimen had enabled me to ascertain.[1]

THE IGUANA.—It may tend to render our remarks on the structure and economy of the Iguanodon more easily comprehended by the unscientific visitor, if we preface those osteological details which the palæontologist will consider indispensable, and without which, indeed, the results that are of general interest could never have been obtained, by a few observations on the nature and habits of the recent lizard, the resemblance of whose teeth to those of the colossal herbivorous reptile of the Wealden suggested the name so familiar to my readers, and by which that extraordinary creature of the secondary ages is now generally known.

The Iguanas are land-lizards which inhabit many parts of America and the West Indies, and are rarely met with north or south of the tropics. They are from three to five feet in length, and are perfectly harmless, feeding on insects and vegetables, and climbing trees in quest of the tender leaves and buds, which they chip off and swallow whole.[2] They nestle in the hollows of rocks, and deposit their eggs, which are like those of turtles, in the sands and banks of rivers.

The dental organs of the Iguana consist of a single row in each jaw of very small, closely-set, pointed teeth with serrated edges, which are not implanted in distinct sockets, but are

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[1] "Notice on the Iguanodon, a newly discovered fossil reptile, from the sandstone of Tilgate Forest, in Sussex." Philos. Trans. 1825. This memoir was printed before the fifth volume of Baron Cuvier's "Oss. Foss." (in which the teeth are figured and described, and mention is made of my discoveries in Tilgate Forest,) had reached this country. See APPENDIX F.

[2] Stuffed specimens of the recent Iguanas are exhibited in that part of the Zoological Gallery approached from Room III. by the entrance between Cases *C* and *D*

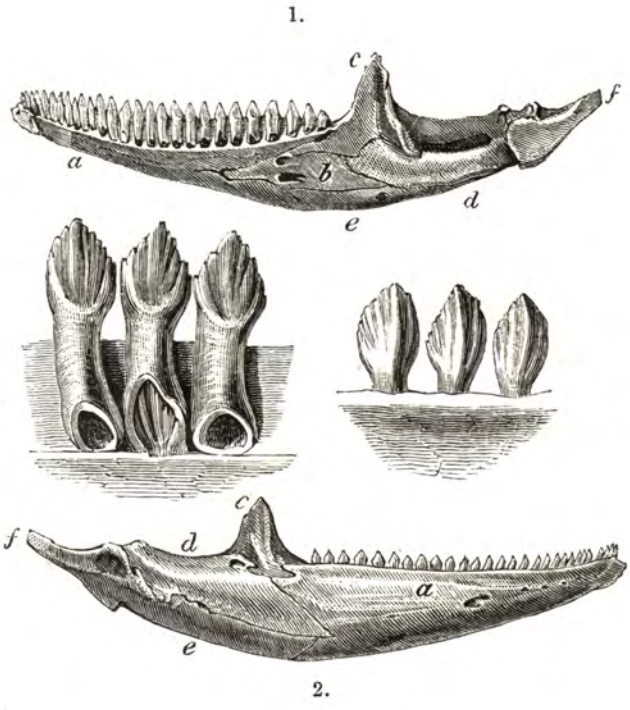
attached by the external surface of the fangs to the inner side of the alveolar process (as is shown in *Lign.* 49); and as there is no mesial parapet of bone, the fangs of the teeth are covered only by the soft parts (*fig.* 1, *Lign.* 49). The successional germs do not, as in the Crocodile, spring up in the cavities of the mature teeth, and rise through them, but are developed near the inner part of the base, and by their upward growth occasion the absorption of the fang of the old tooth, which is ultimately displaced and shed, from the destruction of its adhesion to the alveolar parapet. In *fig.* 3, *Lign.* 49, the position of a germ at the base of the fang is represented.

The teeth of the Iguana closely resemble in form, but not in structure, the perfect young upper teeth of the Iguanodon; they are very small, scarcely exceeding in size those of the mouse. (In *figs.* 1, 2, *Lign.* 49, the teeth are figured of the natural size.) In the Iguana the crown of the tooth never presents a worn or even surface; it is broken or chipped off by use, but not ground smooth as are the teeth of herbivorous mammalia. The reason is obvious: no existing reptiles are furnished with cheeks or moveable coverings to their jaws; they cannot perform mastication, but swallow their food whole.[1]

Lower Jaw of the Iguana.—*Lign.* 49.—Before I quit this subject, and enter upon the examination of the teeth of the Iguanodon, it will be convenient to explain the structure of the lower jaw in reptiles; and I select that of the Iguana, as it will not only serve to illustrate the osteology of that part of the skeleton, but also tend to elucidate the nature of the highly interesting fossils that will hereafter engage our attention.

In mammalia the lower jaw is composed of one bone on each side, and in many genera these pieces become united in front, and blended into a single bone in the adult animal; but in reptiles this element always consists of six distinct pieces on each side, and these several parts are variously

[1] There are some of the large Monitors which can give a semi-rotatory motion to the back teeth; but in no living species of reptile is the trituration of the food effected as in the mammalia and the Iguanodon.



LIGN. 49.—THE RIGHT RAMUS OF THE LOWER JAW OF THE IGUANA TUBERCULATA.

(Presented to the Author by the late Baron Cuvier.)

1.—The right branch of the lower jaw, viewed on its inner aspect: (*nat. size.*)

a. Dentary bone.

b. Opercular bone.

c. Complementary bone.

d. Surangular bone.

e. Angular bone.

f. Articular bone.

2.—External view of the same.

3.—Inner aspect of three teeth (*magnified*) attached to the alveolar parapet, with the germ of a successional tooth at the base of the middle tooth, and the sockets of germs at the bases of the two other mature teeth.

4.—External view of the crowns of three teeth, slightly magnified, in their natural position, appearing above the alveolar ridge.

modified both in shape and arrangement in the different genera.

The form and disposition of the maxillary elements in the Iguana are shown in *Lign.* 49 ; they are distinguished by names which have reference to their office or situation, viz. *a*, the *dentary*, supporting the teeth ; *b*, the *opercular*, or *splenial bone ; c*, the *complementary*, or *coronoid ; d*, the *surangular ; e*, the *angular ;* and *f*, the *articular bone*, which forms the upper and distal portion of the jaw, and includes the depression for the reception of the condyloid end of the tympanic bone, or os quadratum.

In the Crocodiles, Enaliosaurians, and other tribes of reptiles, the elements of the lower jaw are greatly diversified, and a knowledge of their characters is an important aid to the palæontologist in his attempts to ascertain the affinities of the extinct saurians, fragments of whose maxillary organs are oftentimes the sole indications that such types of animal organization ever inhabited our planet.

Teeth of the Iguanodon.—Since the discovery of the tooth which first apprised me of the occurrence of the remains of gigantic herbivorous reptiles in the Wealden, I have collected many hundred specimens of all sizes, and in various conditions, from a minute perfect germ, to the worn-out crown of a molar, ground down above by mastication, and reduced by the upward pressure of a new tooth from beneath, to a mere plate or disk of coarse dentine. In the collection purchased of me by the Trustees of the British Museum in 1838, there were upwards of 150 teeth of the Iguanodon, and among them were the most illustrative specimens then discovered. I have since obtained a few very instructive examples, and some of my friends have good specimens in their collections ; but, certainly, these teeth have of late been less frequently met with than formerly, and I believe the specimens in the British Museum, and those in my private collection, comprise the most characteristic forms hitherto observed.

Lign. 50.—Tooth of the Iguanodon. The perfect crown of a successional tooth. (⅔ *nat. size.*)

The perfect germ, and the unused tooth of the Iguanodon, are characterised by the prismatic form of the crown, the presence of from two to three or four longitudinal

ridges down the enamelled face, and the denticulated lateral margins, and finely serrated edge of the summit, as seen in the specimen figured in *Lign.* 50. The shank, or fang of the tooth partakes of the general form of the crown: it is slightly curved, rather flat anteriorly, and convex on the opposite face, and flattened or compressed at the sides; it gradually diminishes in size towards the base, and terminates in a point; a tooth of this kind in Case *C*, exceeds $2\frac{1}{2}$ inches in length.

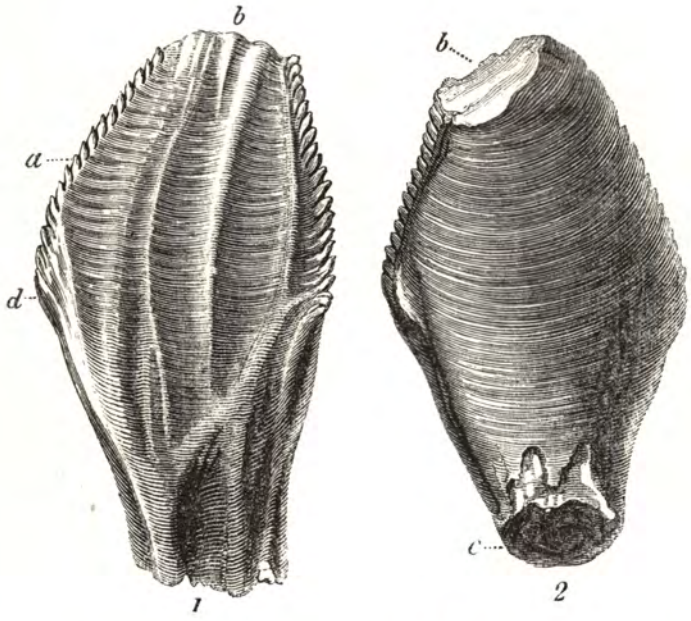
There is considerable variation in the form of the summit of the crown; in the upper teeth it is as angular as in the recent Iguana. (*Lign.* 49, *fig.* 4.) The inner surface of the crown in the lower teeth, and the outer surface in the upper, are covered with a thick layer of enamel, but the sides and the alveolar face of the crown have but a thin coating of this substance.

Specimens with the coronal aspect in its normal state are but rarely met with, for the apex of the tooth is almost always worn away, and the crown presents an oblique, triangular, smooth surface, as in the beautiful example (in my collection) figured in *Lign.* 51, which shows the anterior and posterior aspect of a lower molar, found imbedded in the stem of a Clathraria Lyellii (*see ante*, p. 45), as if the tooth had been snapped off while the animal was in the act of gnawing the tough vegetable trunk. This fossil affords an excellent illustration of the form of the coronal part of a mature molar, the apex of which is but slightly worn away.

The lower part of the root is broken off; in teeth of this kind the fang generally terminates in a point, as in a specimen partially imbedded in a block of Tilgate grit, on the middle shelf of Wall-case *C*. The apex is worn down obliquely (fig. 2. *b*.). The lateral denticulations, which are so peculiar a character of these teeth, are well developed; when seen in front, as in fig. 1, *a*, they appear as mere serrations, but viewed laterally, they are found to be produced by a series of denticulated plates. A transverse section of a tooth of this kind exhibits a simple pulp-cavity in the centre of a body of dentine permeated by calcigerous tubes; with this peculiarity, that the dentine is traversed by medullary canals, which radiate at definite intervals from the centre towards the periphery of the tooth; the dentine of the Igua-

nodon being of a coarser and softer texture than that of other reptiles.

In a series of specimens, the abrasion of the coronal summit by mastication may be traced in every stage, from the slightest wearing away of the apex, and the more decided



LIGN. 51. TOOTH OF AN IGUANODON, WITH THE APEX SLIGHTLY WORN. TILGATE FOREST, (*natural size.*)

1.—Front aspect, showing the longitudinal ridges, and denticulated lateral margins of the crown.

2.—View of the back, or inner surface of the tooth.

a. The denticulated margins.

b. The apex of the crown, worn by use; *b*. fig. 2, shows the oblique smooth surface produced by mastication.

c. A transverse fracture of the fang, showing a section of the pulp cavity occupied by the ossified remains of the pulp.

d. Marks the inferior limit of the denticulated margin; if a line were carried horizontally from *d*, across the tooth, the under figure would represent a tooth worn down below the denticulations, and deprived of its peculiar dental characters, as in *Lign.* 48; it is in this state that the tooth somewhat resembles an incisor of a Rhinoceros.

degradation observable in *Lign.* 51, to the tooth represented in *Lign.* 48,—and which has acquired a classical interest from having been mistaken for the incisor of a Rhinoceros,—in which the lateral denticulations are entirely effaced, down to the deciduous molar, *Lign.* 52, in which the crown is worn

smooth, and the fang entirely absorbed in consequence of the pressure of a successional tooth.

In other specimens in the Museum, the crown is reduced to a mere plate of coarse dentine, flat above, and slightly concave beneath ; a proof that the teeth remained attached to the alveolar process, till the fang was entirely absorbed, and the new crown ready to pierce the gum, and take part in the process of mastication. The removal of the fang by absorption is manifest in almost every specimen, as I pointed out in my earliest memoir on the subject ;[1] and the effect of this process may be traced through every gradation, in like manner as the destruction of the crown of which I have already spoken. Now it is the power of perfect mastication possessed by the colossal reptile to which these teeth belonged, and of which we have such unquestionable proofs in the specimens before us, that is so marvellous a fact to the zoologist, who reflects that the essential conformation of the jaws and teeth in the class Reptilia, as exemplified in existing forms, forbids the supposition that such a structure as is implied by a power of mastication equal to that enjoyed by the herbivorous mammalia, was associated with reptilian organization. As we have already remarked, no living reptiles can masticate their food ; the insects or vegetables on which they feed are seized by the tongue or teeth, and swallowed whole ; so that a moveable covering to the jaws, similar to the lips and cheeks of the mammalia, is not necessary, either for confining substances subjected to the action of the teeth as organs of mastication, or for the purpose of seizing or retaining their prey. The herbivorous reptiles gnaw off the vegetables on which they subsist, but do not chew them ; consequently their teeth, when worn by use,

LIGN. 52.
UPPER TOOTH OF THE IGUANODON : WITH THE CROWN WORN FLAT, AND THE FANG ABSORBED. (*nat. size.*)

[1] "Philos. Trans." 1825.

present a broken or chipped appearance, but not a smooth, flat-worn surface as in the Iguanodon.

INTIMATE STRUCTURE OF THE TEETH OF THE IGUANODON.—Mr. Tomes, F.R.S., whose original and profound microscopic investigations have shed important light on the intimate structure of osseous and dental tissues, has favoured me with the following notes on the organization of the teeth of the Iguanodon.

"The teeth of the Iguanodon present structural peculiarities which, with our present experience in dental tissues, can be confounded with those of no other animal. The enamel is reptilian in character,—that is, it exists as a thin layer, not exceeding the 200th of an inch at the thickest part, and in many places is even thinner; and then it has the usual structureless appearance, with faint wavy markings, in contour lines with the surface of the dentine. Here and there, however, faint lines may be seen proceeding from the surface of the dentine to that of the enamel, which, together with the disposition to break in the direction of the lines, indicates pretty surely the existence of fibres.

"The dentine of the tooth of the Iguanodon is very remarkable when considered in connexion with the position of the animal in the scale of vertebrata. The dentinal tubes are well marked. They make a bold double curve in their passage from the pulp-cavity to the surface, in addition to the minute undulations which characterize them in every part of their course, and in no part are they free from short, minute, ragged, hair-like branches, which in a thick section give a confused appearance to the tissue. In a longitudinal section of a tooth, the tubes have a diameter varying from the 10,000th to the 15,000th of an inch, which is preserved to near their termination at the surface of the enamel, into which tissue a few are continued a perceptible distance. The pulp-cavity is marked by a series of indentations at tolerably regular intervals. From the recesses of these, vascular canals proceed into the substance of the dentine, and follow the course of the dentinal tubes, till near the periphery of the tooth, when they terminate in dilated extremities, or turn and follow a parallel course till they regain the pulp cavity. As the tooth becomes worn, these canals are filled by a transparent, almost structureless tissue, in the manner described in my paper on the teeth of rodents.[1] It should also be remarked that the dentinal tubes are connected with them through their branches only, and by these but sparingly. Professor Owen, in his account of the tooth of the Iguanodon, ('Odontography,' p. 251,) compares the vascular or medullary canals to those which occur in the inner dentine of the tooth of the Megatherium. In the latter, however, the canals are far more numerous than in the Iguanodon, and, moreover, the dentine in which they occur is dissimilar. In it the dentinal tubes are so much interfered with by the very numerous vascular canals that they become irregular, and indeed can scarcely be called tubes; they are irregular cells, minute, and

[1] "Philos. Trans." 1850.

without definite arrangement. In the Iguanodon, on the contrary, the dentinal tubes and their branches are well marked, and definitely arranged.

"On careful comparison it will be found that the dentine of the teeth of this great vegetable-feeding reptile pretty closely resembles that of many of the larger herbivorous mammalia, and more especially the ruminants. In these we find the dentine traversed, though less abundantly, by similar vascular canals. In the American Tapir, and also in the Solipedes, a similar condition is observable. In mammalian dentine the parietes of the dentinal tubes are well marked, especially in the ruminants, where they are extremely thick; this cannot be said to be the case in the Iguanodon, for although the parietes may be seen in a favourable section, yet they are by no means so distinct or so thick; neither, indeed, are the dentinal tubes themselves so large as in the great mammalian herbivora. So far as my own experience goes, the presence of vascular canals in the substance of the dentine as a constant character, is confined to the teeth of the vegetable feeders.

"Professor Owen has described, ('Odontography,' p. 252,) a third substance in the tooth of the Iguanodon. He says, 'The remains of the pulp in the contracted cavity of the completely formed tooth, are converted into a dense but true osseous substance, characterized by minute elliptical radiated cells, whose long axis is parallel with the plane of the concentric lamellæ which surround the few and contracted medullary canals in this substance.' I have seen the concentric lamellæ in the situation described by Professor Owen, and these have been perforated by straggling, irregular, dentinal tubes, but I have failed to observe in this or in any other part of the tooth elliptical radiate cells,—in other words, bone or cement lacunæ.

"In the central part of these teeth, a dark brown matter is commonly seen. This is for the most part composed of small, oval, ferruginous-looking bodies about the size of bone lacunæ, which are surrounded by imperfectly formed crystalline matter. This brown substance occupies the pulp-cavity, and often extends a short distance into the vascular canals. In a thick section it might on a casual inspection be taken for cementum, but a more careful observation would at once show it to be a mere product of fossilization.

"If I had to describe the tooth of the Iguanodon from its tissues in a few words, I should say it was a tooth having herbivorous (mammalian?) dentine, with reptilian enamel."

Lower Jaw of the Iguanodon.—*Ligns.* 54 and 55.—The importance of discovering the peculiar construction of the maxillary organs which had impressed such anomalous characters on the teeth of a reptile, as to impart to those instruments so striking a resemblance to the incisors of herbivorous mammalia as to mislead the most eminent anatomist of modern times, could not be estimated too highly; and for many years, my curiosity and interest were painfully excited by the desire of solving the mystery in which the subject

was involved; but nearly a quarter of a century passed by ere that privilege was attained.

Although the specimen I am about to describe does not belong to the national collection, yet it throws so much light on the subject under review, and imparts such additional interest to the objects before us, that I feel assured the intelligent reader will not consider the following somewhat minute description of the first discovered portion of the lower jaw of the Iguanodon, as irrelevant to the immediate purpose of this volume.

Lower Jaw of the Iguanodon.[1]—*Lign.* 53 and 54.—In the deltas and estuaries of rivers which flow through countries of varied geological structure, we naturally expect to find the remains of terrestrial vertebrated animals that have been transported by the currents from far distant lands, in a more or less mutilated state; the skeletons broken up—the bones dissevered, fractured, and waterworn—the teeth detached from the jaws and dispersed—and all these separated parts promiscuously imbedded in the mud, silt, and sand of the delta, and intermingled with the debris of the flora of the country, and the remains of fishes, mollusks, and crustaceans, that inhabited the fresh water, or were denizens of the adjacent sea. Such, as we have already pointed out, is the condition in which the bones and teeth of oviparous quadrupeds are found in the Wealden formation, and hence the difficulty of obtaining satisfactory evidence of the form and structure of the extinct reptiles whose relics are so abundant in some of the deposits.

To this cause may be ascribed the remarkable fact, that although many hundred teeth, belonging to several genera of saurians, have been collected from these fluviatile strata, scarcely a portion of the cranium, and but a few fragments of the jaws, have been discovered. Every relic of this kind is consequently in the highest degree interesting, and it was,

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[1] The following account of the maxillary organ of the Iguanodon is an abstract of my Memoir, "On the Structure of the Jaws and Teeth of the Iguanodon," communicated to the Royal Society in May, 1848, and published in the "Philosophical Transactions" of the same year. The Royal Medal of the Society was awarded to the author for that communication.

therefore, most gratifying to me to learn that at length a considerable portion of the lower jaw, with teeth, of an Iguanodon, had been obtained from the quarry near Cuckfield, in Sussex, in which the teeth of this colossal herbivorous lizard were first discovered.

In a communication addressed to the Royal Society in 1841,[1] I figured and described a fragment of the lower jaw of a small reptile as, probably, that of a young Iguanodon, and the anatomical considerations which seemed to support that interpretation were fully detailed. But although, from the form and the mode of implantation of the fangs, which are the only vestiges of the teeth in the specimen, and the position of the germs of the successional ones, this inference appeared to me highly probable; yet, as the crowns of the teeth were wanting, the presumed generic identity could not be established, since it was possible the fossil might belong to the Hylæosaurus, or to some unknown genus of reptiles whose bones occur in the Wealden deposits, as afterwards proved to be the case.

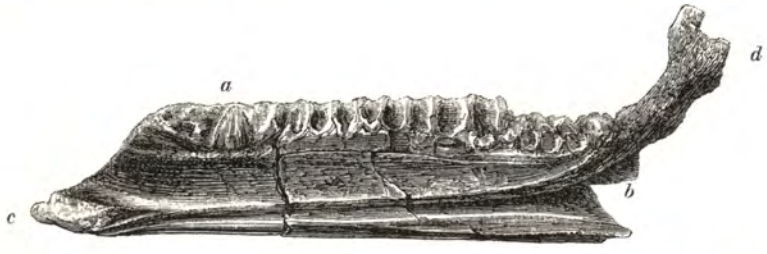
But the specimen to which I now solicit attention is the right side of the lower jaw of an adult animal, with two successional teeth in place, and the germ of a third, and the alveoli or sockets of seventeen or eighteen mature molars, and is the first indisputable portion of the jaw of the Iguanodon which has hitherto been brought to light; and although, from the absence of mature teeth, and of the articular portion of the jaw, this specimen does not afford a complete solution of the problem discussed in the preceding pages, it possesses characters sufficiently definite and intelligible to throw important light on the structure and functions of the dental organs of the Iguanodon; and it has also enabled me to determine the nature of a portion of the left upper maxillary bone, collected many years since, and now in the British Museum, but which I was previously unable to interpret.

Before entering upon the description of this unique and most interesting fossil, I must express my warmest acknowledgments to Captain Lambart Brickenden, of Warminglid, Sussex (now of Elgin, Scotland), by whom it was discovered, and skilfully extricated from the sandstone in which it was

[1] "Philos. Trans." 1841, p. 131.

imbedded, and who, although I was personally unknown to him, in the true spirit of an ardent cultivator and liberal promoter of science, placed it at my disposal, as the original discoverer and investigator of the fossil saurians of the Wealden ; a tribute of respect that I regard as a high reward for my humble efforts to advance that department of natural knowledge, to which I have devoted the leisure moments of a life of professional toil.

This specimen was found imbedded in a block of the fawn-coloured sandstone which occurs interstratified with beds of clay and limestone, throughout a considerable part of the Wealden districts of the south-east of England ; fortunately this stone is not very compact, so that the organic remains it contains may be extricated by a skilful manipulator, with but little difficulty. It consists of the dentary, and part of the coronoid or complementary bone, of the right side, and is entire at the anterior part ; but the posterior or opposite extremity is imperfect, probably to the extent of several inches. Its original relative position in the jaw will be understood by a reference to *Lign.* 49, in which the peculiar construction of the lower jaw in the Iguana is exemplified.



LIGN. 53.—RIGHT SIDE OF THE LOWER JAW OF THE IGUANODON, FROM TILGATE FOREST, DISCOVERED BY CAPTAIN LAMBART BRICKENDEN, F.G S.
(The inner aspect : $\frac{1}{7}$ nat. size.)

The specimen is represented of the natural size in the "Philos. Trans. for 1848," Pl. XVI., of which *Lign.* 53, and 54, are reduced sketches ; its dimensions are as follow :—

	Inches.
Length from the front of the symphysis to the posterior extremity of the bone	21
Greatest width of the outer surface measured over the convexity, from the lower margin to the upper alveolar edge	$6\frac{3}{4}$

	Inches.
Greatest thickness at the posterior part	$2\frac{3}{4}$
Length of the alveolar parapet for twenty teeth . . .	15
Breadth from the anterior termination of the alveolar space across to the inner margin	$4\frac{1}{4}$
Height of the alveolar parapet at the posterior part. .	2
Width of the alveolar space at the posterior part . . .	$1\frac{1}{4}$
Width of the alveolar space at the anterior part . . .	$\frac{3}{4}$
Length from the first anterior tooth to the symphysial extremity	5
Height of the successional tooth (*a*, *Lign.* 53) $1\frac{1}{2}$ inch; greatest width $\frac{7}{8}$.	

The mesial or inner aspect of the fossil (*Lign.* 54) is flat and smooth; it shows the crown of a large successional tooth, (*a*,) and the small germs of two other teeth, in their original situations, and the sockets for nineteen or twenty teeth; the inner alveolar plate having been destroyed, and the mature molars dislodged, before the bone was imbedded in the rock. The deep conical groove or furrow, so constantly present on the inner side of the dentary bone in reptiles (and which, from its being covered by the splenial or opercular piece, it may be convenient to designate the *opercular furrow*), is here entirely exposed (*b*), in consequence of the removal and destruction of that maxillary element. It is very large, and prolonged anteriorly to within six inches of the symphysis; the opercular piece, in its elongated form, must, therefore, have more nearly corresponded with that of the Varanians or Monitors than with the Iguanas, in which it is of a rhomboidal figure, and relatively of limited extent. The lower margin of the jaw is thick and convex at the posterior part, and gradually becomes thinner towards the front, where it expands horizontally into a broad scoop-like process, which is terminated anteriorly by an obtuse projection or tubercle (*Lign.* 54, 55, *c*); it thins out mesially to form the symphysial suture that connects it with the opposite ramus.

The upper margin is formed by the alveolar process, which has a thick external parapet, deeply furrowed on the inner side by the sockets for the mature teeth; strongly-defined ridges occupy the interspaces, and rising above the sockets, produce a sharp crenated upper border on the alveolar ridge. The alveolar space is protected on the inner side by a moderately strong plate or wall, which must originally have almost equalled the outer parapet in height, but is now in a great

measure broken away; within this process the germs of the successional teeth were developed.

The mode of implantation of the teeth appears to have been intermediate between the pleurodont and thecodont types, for the teeth were not anchylosed to the alveolar wall as in the Iguanas; yet as the ridges that separate the dental sockets are smooth and rounded, it may be inferred that these were not rendered complete alveoli by transverse plates extending from the outer to the inner parapet, as is the case in the Megalosaurus.[1]

The dental sockets diminish in size, but somewhat irregularly, from the posterior to the anterior termination of the alveolar process; and the latter suffers a corresponding diminution in breadth, and terminates suddenly at the distance of five inches from the front. At this point the upper margin becomes attenuated and contracted in a vertical direction, and descending with a gentle curve, expands horizontally and mesially to unite at the symphysial suture with the opposite ramus; the anterior part of the jaw being edentulous.

From the fortunate preservation of two successional teeth in their original position, the mode of dental development in the Iguanodon is clearly demonstrated. As in existing saurians, the germ of the coronal portion of the tooth was first secreted, and the entire crown completed before the formation of the shank or fang commenced. The formative pulp was situated in a distinct depression or cavity, on the inner face of the root of the tooth it was destined to supplant: this is obvious by the position of the teeth above described; and also by the remains of a third germ, which is observable towards the posterior part.[2]

Although the peculiar characters of the molars of the Iguanodon have already been described somewhat in detail, and the present fossil confirms in every essential particular the inferences suggested by the detached teeth, yet several new and important points relating to the development and functions of the dental organs, are elucidated by the new

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[1] See Dr. Buckland's "Bridgewater Essay," Pl. 23.

[2] A reference to the lithograph in the "Philos. Trans." Pl. XVI. representing the specimen of the natural size, is necessary for the full illustration of this description.

acquisition which Captain Brickenden has so generously placed at my disposal, The second tooth, which occupies its natural position in the alveolar space, consists of a perfect crown, $1\frac{1}{2}$ inch in height, with the serrated margin as sharp as when recent; and this was the first evidence obtained as to the mode in which the teeth were implanted. The flat enamelled face of the tooth, characterized by its longitudinal ridges, is placed mesially, or *towards the inside of the mouth*, and parallel to, and within the inner alveolar wall; the smooth convex part of the crown fills up a depression in the outer parapet, in the interspace of two sockets of the mature molars. This position is the *reverse* of that in which the successional teeth in the Iguana are developed; for in that reptile the coronal germ occupies the same relative place as in the mature state, the ridged face being outwards, and the smooth side inwards, or towards the cavity of the mouth.

As the crown of the tooth in the Iguanodon is not symmetrical, one lateral margin presenting a gentle curvature, and the other forming a broad angle at the base of the serrated border, the teeth belonging to one side of the lower jaw may readily be distinguished from those of the other; the lateral marginal angle being always situated posteriorly. Guided by this character, Dr. Melville and myself examined the numerous teeth in the British Museum and in my own collection, and were enabled to ascertain to which ramus or side of the jaw any tooth belonged. Thus, for example, the specimen represented, *Lign.* 50, which is a perfect successional germ, the counterpart of that implanted in the jaw, consisting of the crown before the formation of the fang, belongs to the right side.

The situation of the germ in relation to the tooth it was destined to supplant, is invariably on the inside of the mouth; in the lower molars the excavation in the mature tooth occasioned by the upward growth of the germ, is consequently on the enamelled mesial or inner face, as is shown in my original memoir:[1] in the upper tooth the germ was lodged in an excavation on the smooth convex aspect.[2]

In some examples the cavity produced by the pressure of

[1] "Philos. Trans." 1825, Pl. XIV. fig. 7 *a*.
[2] "Philos. Trans." 1848, Pl. XVIII. fig. 2^a, *f*.

the germ is at the bottom of the fang of the tooth in place; in others, the successional dental excavation is on the base of the enamelled crown; for in the Iguanodon the old teeth were retained till nearly the entire coronal portion was worn away, and the crown of the tooth, from the abrasion by use above, and the removal of the fang by absorption below, was often reduced to a mere disk, before it was finally shed. [1]

As the surface of the crown, when abraded by mastication, possesses two distinct facets, it is obvious that the arrangement of the lower teeth in relation to the upper was intermediate, or subalternate, as is the case in the ruminants.

The *external aspect* of the specimen[2] (*Lign* 54) presents in its transverse diameter a gentle convexity, traversed by a slightly elevated longitudinal ridge, parallel with, and immediately beneath, the row of vascular foramina commonly met with in this part of the lower jaw in reptiles; and towards the posterior extremity, the side of the bone is somewhat com-

LIGN. 54.—EXTERNAL VIEW OF THE LOWER JAW OF THE IGUANODON.
(⅛ nat. size.)

pressed below the longitudinal eminence; agreeing in this respect with the portion of a lower jaw of a much smaller reptile, to be described hereafter.[3] The upper margin of the bone is formed by the outer alveolar parapet, which is deeply scalloped or crenated by the terminations of the sockets of the teeth; the angular eminences indicate the intra-alveolar

[1] "Philos. Trans." 1848, p. 188.

[2] Figured in "Philos. Trans." 1848, Pl. XVI. XVII.

[3] Described in "Philos. Trans." 1841 (Pl. V. figs. 1, 8, 9), as part of the jaw of a young Iguanodon, but which belongs to a distinct genus—the *Regnosaurus*.

ridges. The whole surface is covered with minute punctuations and striæ.

The numerous and large vascular foramina which afforded passage to the vessels and nerves from the dental canal to the external integuments, form a striking character in this aspect: they open obliquely forwards; nine are distributed at regular intervals in a line with the alveolar margin, from the posterior end of the bone to nearly opposite the successional tooth in place. A fracture in the middle of the outer surface, at the distance of $4\frac{1}{2}$ inches from the posterior end, exposes the dental canal filled with sandstone: its diameter is here two-fifths of an inch.

At the anterior termination of the alveolar space, a slight protuberance marks the commencement of the upper margin of the symphysial region, which is defined by a sharp smooth ridge, that sweeps downwards and inwards to form the front of the jaw. A deep groove, beset with foramina, constitutes a strong line of demarcation between the inner and outer boundary of this area; the latter is thick and convex, and terminates anteriorly, as already mentioned, in a mammillary protuberance or tubercle. A series of foramina, eight in number, extends along the outer and inferior surface of the symphysis; the terminal one, which is three-fourths of an inch in its transverse diameter, is situated immediately under the mental tubercle (*c*) above described. The mesial or inner edge of the symphysis, which in connexion with the ramus of the left side formed the median suture of the lower jaw, is thin and expanded; the articulating surfaces of the two dentary bones appearing to have overlapped each other, but as the edge of the bone is somewhat broken, the line of junction is not quite determinable; but the two rami do not seem to have been united by anchylosis. On the under surface of the symphysis there is a depressed oval area, bounded laterally and posteriorly by a slightly elevated ridge, probably for the insertion of the protractor muscles of the tongue. The coronoid bone (*d*), which is incomplete, is expanded more outwardly than in any recent saurian.

With respect to the length of the jaw to which this specimen belonged, an approximative estimate only can be formed, since we have no means at present of determining the relative size of all the different pieces that entered into the construc-

tion of the maxillary organs of the Iguanodon. From the appearance of the fractured end, it seems probable that the dentary bone was prolonged backwards five or six inches before it united with the sur-angular and angular: upon this supposition the entire length must have been two feet, and the number of teeth about twenty. In the Iguana and most Lizards the dentary element is half the length of the jaw; and if this proportion be taken as the standard of comparison—and it appears to be the most probable one—the length of the jaw of this individual was four feet. An eminent palæontologist[1] has estimated the length of the head of the largest Iguanodon at only thirty inches; having taken as the basis of his calculation, the length of six dorsal vertebræ, which in the Iguana is equal to that of the lower jaw. But the specimen before us proves either that the same scale of proportion is not applicable to this colossal saurian, or that much larger dorsal vertebræ than those from which the measurement was taken, are yet to be discovered; for several teeth in my possession exceed in magnitude the largest sockets of this dentary bone. Even if we take the abbreviated proportions of the short blunt-headed lizards as the scale

LIGN. 55.
RESTORED FIGURE OF THE LOWER JAW OF THE IGUANODON. SEEN FROM ABOVE.
($\frac{1}{12}$ *Nat. size.*)

[1] Reports of the British Association for 1841. Article, "British Fossil Reptiles," p. 143. "If there be any part of the skeleton of the

—as for example the Chameleons—the length of the jaw of this Iguanodon must have exceeded three feet.

The sketch of the lower jaw, represented as seen from above, in *Lign.* 55, is intended to convey an idea of the remarkable form of this part of the skeleton; the restoration of the articular part, drawn in outline, is of course ideal; it is taken from the corresponding portion of the lower jaw of the Iguana.

Portion of the Upper Jaw of the Iguanodon.[1]—*Middle Shelf of Wall-case C.*—This specimen consists of the anterior part of the left maxillary bone, having on the under surface the alveolar furrow with the bases of the sockets of ten teeth; and on the upper, the deep channels of the infra-orbital vessels and nerves that supplied the teeth and integuments of the front of the jaw and face on the left side. Dr. Melville,[2] who kindly aided me by his profound anatomical knowledge in the investigation of the maxillary organs of the Iguanodon, and devoted much time and attention in instituting the necessary comparisons between the fossils in my own cabinet and those formerly collected by me, and now in the British Museum, with the jaws and teeth of recent reptiles, favoured me with the following observations on this specimen:—

"This fragment of the left maxilla, which is eight inches five lines long, and two inches seven lines broad, formed the lower boundary of the nasal surface; it is broken off where the vertical parapet rises to enclose the olfactory fossa. The corresponding part in the skull of an Iguana (*I. tuberculata*), measuring four inches two lines in length, is six lines long, or nearly one-eighth that of the cranium; this ratio gives

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"Iguana which may with greater probability than the rest be supposed to have the proportions of the corresponding part of the Iguanodon, it is the lower jaw, by virtue of the analogy of the teeth and the substances they are adapted to prepare for digestion. Now the lower jaw gives the length of the head of the Iguana, and this equals the length of six dorsal vertebræ; so that as five inches rather exceeds the length of the largest Iguanodon vertebra yet obtained, with the intervertebral space superadded, on this calculation *the length of the head of the largest Iguanodon must have been two feet six inches.*"

[1] I discovered this fossil in 1838, in a quarry near Cuckfield. By the kind permission of Mr. König, the specimen has recently been cleared of the sandstone with which it was partially invested, so as to render its characters more obvious. It is figured in "Philos. Trans.," 1848. Pl. XIX.

[2] Now Professor of Zoology in Queen's College, Galway.

five feet four inches as the length of the skull of the Iguanodon to which the fossil belonged; but as the brain and the organs of sense would probably bear a less proportion to the whole bulk in these gigantic saurians than in the small species of existing Lizards, we may infer a diminution in the absolute size of the head, corresponding with the abbreviation and contraction of the cranium; and the length in the adult Iguanodon would probably average about four feet.

"The breadth of the fragment is uniform; in front it is rounded off externally, and exhibits the oblong terminal irregular surface for articulation with the intermaxillary bone by which it appears to have been overlapt. The large infra-orbital canal opens at the junction of the posterior and middle third, and midway between its margins passes into a broad and deep and sigmoid groove, which curves inwards as it advances, so as nearly to reach the inner edge in the centre of its course, where it gives off a retrograde furrow extending over the internal margin.

"The infra-orbital canal, which is eight lines wide behind and four lines high, bends inwards as it retrogrades from its anterior opening. The inner surface is only four lines from the nasal aspect of the fragment behind, so that after a course of a few inches, it would have emerged on the floor of the nasal cavity. The roof is incised obliquely outwards, and the inner portion of it extends forwards to the retrograde groove. The portion of the external surface of the alveolar process that remains, slopes inwards, and exhibits no traces of vascular foramina."

From the almost entire destruction of the inner walls of the alveolar furrow, deep transverse grooves are the only indications of the dental sockets. As the fangs of the teeth of the upper jaw were more curved than in the lower series, their implantation presented a corresponding modification, as is the case in the dental organs of certain existing Monitors; hence the width of the alveolar space is greater than in the lower jaw.

Distinctive characters of the Upper and Lower Teeth.—Although the peculiar characters which distinguish the teeth of the Iguanodon from those of all other animals were satisfactorily established from the numerous detached specimens that had come under my observation, yet as the mode in which the teeth were implanted in the jaws was then unknown, no attempt was made to ascertain the dextral or sinistral position of the isolated teeth, nor to separate the lower from the upper series, and thus determine the dental arrangement by which the jaws of this colossal reptile were invested with the functions of those of the existing herbivorous mammalia. To ascertain these important questions it became necessary to institute a rigorous examination and comparison of all the teeth of the Iguanodon to which we

could obtain access; the following are the results of our investigation.[1]

Teeth of the Lower Jaw.—The lower tooth (*Lign.* 50 and 52, 3, 4,) is curved with the concavity outwards, or towards the external alveolar parapet; the upper and lower limbs, corresponding respectively to the wedge-shaped crown, and elongated taper fang, are not separated by a constriction or neck, but are flattened in opposite directions. In the upper moiety of the coronal segment, it is compressed transversely with an outer convex, and a flat inner aspect, and gradually increases downwards in width and thickness, from the broad-rounded eccentric apex to its greatest longitudinal diameter. It continues to expand transversely while decreasing in breadth, and subconcave planes replace the serrated edges at which the surfaces meet above; it obtains its greatest thickness where the tooth bends and forms the fang, which diminishes rapidly in both diameters, and the lateral facets are brought in contact below, and obliterate the inner surface; in fully formed teeth when a successional germ is not developed, the fang terminates in a point.[2]

The enamelled surface is divided into two unequal channelled areas by a primary longitudinal ridge; commencing at the apex, it intersects the long diagonal, and terminates behind the lower angle.

The relative width and depth of the longitudinal grooves, and the prominence of the intervening ridges, vary in different specimens. The serrations are produced by small mammillated ridges, separated at slight intervals; the inner edges of the anterior apical ones are prolonged downwards, and those on the posterior margin are abraded, apparently by absorption, during the upward growth of the germ. The inner convex surface of the fang is in apposition with the outer alveolar parapet. The lateral planes converge inwards, and are grooved longitudinally; they extend as high as the obtuse angle of the crown, and leave between them, as they diverge in their ascent, an unenamelled triangular space on the inner

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[1] The details of this examination are given by Dr. Melville in the memoir referred to, "Philos. Trans." 1848, pp. 191—195.

[2] "Philos. Trans." 1841, Plate VII. figs. 1, 2. A specimen of this kind is placed on the middle shelf of Wall-case *C*.

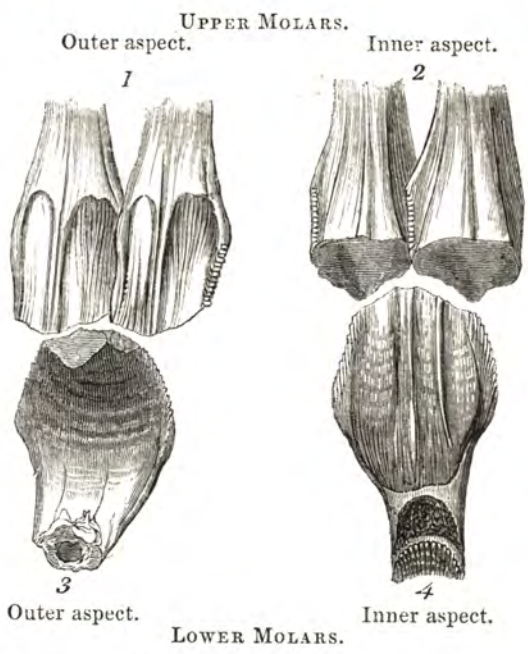
aspect. Expansions of the alveolar septa on each side are adapted to the lateral planes of the fang, and the inner parapet is deficient opposite the triangular tract above-mentioned, but is closed below, and separates the alveolus from the cavity of reserve in the secondary dental groove.

The teeth never become anchylosed to the sockets; the great transverse diameter of the dentary element of the jaw above appears to have allowed of the outward curvature of the elongating fang, while the inner surface was maintained nearly vertical. By the same provision the germ attained a considerable size before it pressed upon and excavated the root of the tooth it was destined ultimately to displace. The wedge-shaped crown and the anterior serrated recurved trenchant edge, must have rendered the teeth in this early stage very efficient instruments, in the absence of incisors, for cutting vegetable food.

The arrangement of the upper and lower molars, and the situation of a lower successional germ, are shown in *Lign.* 56, in which two upper molars of the right side are represented on their external or enamelled aspect, and a corresponding lower molar beneath them: in *fig.* 2, are shown the opposite or internal aspect, and the position of a successional germ in the fang of the lower tooth, *fig.* 4.

Teeth of the Upper Jaw.—Lign. 56, 1, 3.—After the determination of the form and position of the teeth of the lower jaw, the next question to be determined was, whether the teeth in the upper maxilla had the same shape and curvature as those of the lower. Upon examining the extensive series in the British Museum, several teeth were found differing in shape from the now-ascertained type of the lower molars of the Iguanodon; these, however, so closely correspond in all essential respects, that no reasonable doubt can exist of their having belonged to the upper jaw of the same species of reptile. From the mutual adaptation of the grinding surfaces, and the situation of the excavation produced by the replacing germ—which in all analogous cases is in the mesial aspect of the fang—the inference was obvious that these teeth not only did belong to the upper series, but that they were curved in an opposite direction to those of the lower; namely, with the convexity external, and the concavity internal; the hollow for the successional germ being

situated in the latter. If this interpretation be correct, then the upper and lower molars were related to each other nearly



Lign 56.—Upper and Lower Teeth of the Iguanodon, in their presumed natural arrangement.

($\frac{2}{3}$ *nat. size.*)

Fig. 1.—Two upper molars, the crowns worn by use; the external aspect showing the ridged and enamelled face.
2.—Inner aspect of the same.
3.—A mature lower molar; the external aspect; exposing the two oblique facets worn by friction against the pair of upper teeth.
4.—Inner aspect of a lower molar, displaying the longitudinal ridges, and serrated edges; a coronal germ of a successional tooth is seen in a cavity at the base of the fang.

as in the Ruminants; the outer aspect below corresponding to the inner above; the triturating facet inclining from above downwards and outwards in the inferior series, and from below upwards and inwards in the superior; in the lower teeth the enamelled edge is within and the most elevated, while in the upper it is external and the lowest.

By this adjustment the harder dentine with its coating of enamel, played on the softer vaso-dentinal tract of the tooth opposed to it below; and a bevelled or chisel-like surface was maintained for triturating the food when drawn into the

mouth by the large prehensile tongue, which is indicated by the procumbent and inferiorly excavated symphysis. The upper molars are also distinguished by the smaller antero-posterior diameter of the crown—by the great prominence of the primary ridge—by the breadth of the vertically convex surface of the fang—by the width of the lateral facets—and by the contraction of the internal or vertically concave surface which becomes ridge-like below.[1]

As it is very rarely that a specimen occurs in which the absorption of the fang, from the upward growth and pressure of a new tooth, has not taken place in a greater or lesser degree, it is evident that the formation of successional teeth was in constant progress at all periods, as is the case in most saurians.

We have seen that the internal structure of the teeth is in striking accordance with the external form and mechanical arrangement of the dental organs; for the central body of dentine or tooth-ivory is of a softer and coarser texture than in any known reptiles, and closely resembles that of the large herbivorous mammalians. The peculiar arrangement of substances of different degrees of hardness, must have rendered the teeth in every stage instruments admirably adapted for the trituration and comminution of vegetable substances. The dental pulp became ossified in the old teeth, so that whatever the degree of abrasion, the exposed masticating surface was solid. This is seen even in the last stage, when the crown is reduced to a mere plate or disk of dentine.

Tympanic Bone.—*Wall-case C,* see p. 227.—As the articular piece which contains the socket of the lower jaw for receiving the inferior head of the *os quadratum* is unfortunately wanting, the mechanism of the articulation of the jaws can only be conjectured; for although a very fine example of the tympanic bone—which in reptiles as in birds connects the lower with the upper maxilla—is preserved in my former collection, the specimen is not sufficiently perfect to indicate the adjustment of these parts of the maxillary organs.

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[1] The distinction between the upper and lower molars was first suggested, and subsequently worked out and established by Dr. Melville.

A large bone of this kind from Tilgate Forest, which I refer to the Iguanodon, approximates in many respects to that of the Mosasaurus (*ante*, p. 196.) The body bears some resemblance to that of a vertebra, but the large cells and hollows which pervade it throughout readily distinguish it. It forms a thick pillar or column, which is contracted in the middle, and terminates at both extremities in an elliptical and nearly flat surface. Two lateral processes pass off obliquely, and are small in proportion to the size of the column. On placing this fossil beside the homologous bone of the Iguana, we at once perceive that the relative proportions of these parts are reversed; for in the latter the pillar is small and the lateral processes large.

From the great size of the body, and the extreme thinness of its walls, the tympanic cells must have been very considerable in number and magnitude, and have constituted a large portion of the auditory cavities. This bone is 6 inches high, and $5\frac{1}{2}$ inches in its greatest diameter. It is larger than the tympanic bone of the Mosasaurus, and exceeds by 14 times in linear dimensions that of an Iguana, four feet long. This specimen is figured on a reduced scale in the "Geology of the S. E. of England," Pl. XI. fig. 5.

Spinal Column of the Iguanodon.—*Wall-case C.*—(*ante*, p. 138.)—The bones composing the vertebral column are the most important elements, and at the same time the most numerous remains of the skeleton, that occur in the Wealden deposits; but, unfortunately, the structure of the neural arch and its processes renders the characteristic parts of the vertebræ so liable to injury, that it is but rarely the specimens imbedded in the rocks are in a perfect state, or can be extricated entire. For reasons previously mentioned, connected portions of the skeleton are but seldom met with in fluviatile deposits; hence, but few examples of vertebræ in juxtaposition have been obtained. Of the Iguanodon but one specimen has been discovered, exhibiting the cervical, dorsal, lumbar, and caudal, vertebræ of the same individual.

The difficulty of arriving at any satisfactory conclusions as to the generic relations of the mutilated vertebræ which were among the earliest indications of the Wealden reptiles at the commencement of my researches, can scarcely be conceived

by the anatomist of the present day, who is surrounded by the richest osteological museum in the world, and has spread before him the collections made during the last thirty years by diligent labourers in the field, who discovered the bones in the strata, and with their own hands extricated and developed them from the rock, unaided by pecuniary rewards from associations, or societies, or by government grants; and who toiled on, actuated solely by that ardent thirst for knowledge, and desire to advance a favourite science, which the genuine worker and searcher after truth can alone comprehend and appreciate. If the Hunterian Professor, with the immense advantages which are at his command, and standing on a pinnacle raised by the labours of "genuine workers and searchers after truth," sometimes feels embarrassed, and in extenuation of mistaken interpretations of dismembered portions of skeletons, finds it necessary to observe,—that, "Above all things, in our attempts to gain a prospect of an unknown world by the difficult ascent of the fragmentary ruins of a former temple of life, we ought to note the successful efforts, as well as the occasional deviations from the right track, with a clear and unprejudiced glance, and record them with a strict regard to truth:"[1]—how much more may the original discoverer, explorer, and interpreter of "the fragmentary ruins of former temples of life," up which the Hunterian Professor has ascended, claim indulgent consideration for *his* guesses at truth, from those who have so greatly profited by them; and deprecate the "unamiable exaggeration" of his imperfect investigations, and the disparagement of his labours, and the "misrepresentations," that appear in the Monograph from which the above admonition is extracted.

Vertebral Column.—The structure of the middle dorsal, and anterior caudal vertebræ of the Iguanodon, was first made known by the figures and descriptions in my various works on the Geology and Fossil remains of the South-East of England; and subsequently established by the discovery of corresponding bones in the Maidstone specimen, associated with other parts of the skeleton; for although the vertebræ in that fossil are greatly distorted, their distinctive characters may be recognised by due attention.

[1] "Monograph on the Fossil Reptilia of the Cretaceous Formation." Palæontographical Society, 1851, p. 83.

In 1841, the elaborate and critical examination of all the saurian vertebræ from the Wealden, collected by myself and others, in the able "Reports on the British Fossil Reptiles," established some important diagnostic characters by which the isolated parts of the spinal column of several genera of reptiles, whose remains are found promiscuously imbedded in those deposits, might be identified. But the determination of the cervical, anterior dorsal, lumbar, and terminal caudal of the Iguanodon is not, even now, satisfactorily accomplished; for although, in my earlier attempts to interpret the dissevered parts of the skeletons which were from time to time exhumed, certain large vertebræ of dissimilar forms were vaguely assigned to the Iguanodon,—rather from their collocation with undoubted bones of that reptile, and the absence of remains of the extremities of other genera to which they could have belonged, than from their anatomical characters,—many of these bones have since been referred to distinct genera, upon grounds scarcely more valid.[1]

Among the vertebræ I have obtained of late years, are cervicals, anterior dorsals, and posterior caudals, which so closely approximate in their essential characters to the known vertebræ of other parts of the spinal column of the Iguanodon, as to render it highly probable that they belong to that animal; and although, in the absence of connected portions of the different regions of the spine, absolute certainty cannot be obtained, the typical affinity of the bones in question appears to support this view of the subject, rather than that which assigns them to distinct genera, of which no other less questionable vestiges have been discovered in the same deposits.[2]

[1] See "Reports on British Fossil Reptiles," vol. for 1841, pp. 88—94.

[2] In a work like the present, I can only state the general result of a careful examination of all the specimens to which Dr. Melville and myself could obtain access; and I would refer to my "Memoir on the Osteology of the Iguanodon and Hylæosaurus in "Philos. Trans. for 1849," p. 271, for figures and details. I may add that, during the last year my private collection has been enriched by upwards of thirty vertebræ, among which are larger and more perfect dorsals of the Iguanodon than any previously discovered; others are cervicals, dorsals, and caudals, of allied genera. Should Providence grant me life and health to continue these investigations, I hope to obtain some highly important results, and advance our knowledge of the structure and economy of the stupendous saurians of the Wealden, whose osteology is still but very imperfectly worked out.

In the "Geology of the South-East of England" (p. 307), several large convexo-concave vertebræ from Tilgate Forest are described as presenting the true lacertian form, being concave anteriorly, and *convex posteriorly*, as in the Iguana, Monitor, Crocodile, &c.; but in 1841, Professor Owen ascertained that the relative position of these vertebræ in the skeleton was the reverse of the ordinary type, the *convexity being anterior*, and the *concavity posterior*. A similar deviation from the usual rule had long previously been detected by Baron Cuvier, in a fossil crocodilian found at Honfleur, (figured and described in "*Ossemens Fossiles*," tome v. p. 155); and which was referred by Geoffroy St. Hilaire to the genus *Steneosaurus*, but has since been named by Herm. von Meyer, *Streptospondylus* (reversed spine); an objectionable term, since the same character is present in several fossil genera, as well as in existing mammalia; and the vertebræ from Tilgate Forest were assigned by Professor Owen to the same genus as *Streptospondylus major*.[1]

But notwithstanding the high respect I entertained for the profound anatomical knowledge of the Hunterian Professor, I could not divest myself of the idea that this opinion was untenable, from the fact that all the convexo-concave vertebræ hitherto found in the Wealden were cervical; it was, indeed, this circumstance, together with the extreme rarity of this type, which deterred the Rev. W. D. Conybeare and myself, at the commencement of my researches, from assigning them to the Iguanodon.[2]

The inspection of a large anterior dorsal vertebra of the convexo-concave system in my collection, first suggested to Dr. Melville the idea that this bone, as well as the cervicals above mentioned, belonged to the Iguanodon, and he spared neither time nor trouble in endeavouring to ascertain the correctness of this opinion: to him, therefore, alone is due the

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[1] "British Association Reports," 1841, p. 91. The eminent author appears, however, to have entertained some doubts whether the vertebræ in question might not belong to his genus "*Cetiosaurus*;" but he dismisses the suspicion with the remark, "that the general constancy of the vertebræ of the same Saurian in their antero-posterior diameter forbids the supposition of a vertebra six inches in length in the neck, being associated with one three inches in length in the back," p. 96.

[2] See "Geology of the South-East of England," p. 307.

merit of having first interpreted the characters of this important part of the skeleton, should future discoveries confirm this view of the subject.

The gradual transition from the anteriorly convex cervicals, to the plano-concave vertebræ of the posterior dorsal and lumbar regions, appears,—at least in the absence of the only certain evidence, a naturally connected spinal column,—to warrant the conclusion that all these vertebral elements are referable to the same gigantic herbivorous saurian.[1]

I proceed to point out the most instructive examples of the vertebræ which, according to the present state of our knowledge, are referable to the Iguanodon.

Convexo-concave Cervical Vertebræ. *Wall-case C.*—The two anteriorly convex cervicals above referred to, are on the upper shelf, immediately to the left of the slab containing six caudal vertebræ, in the lowest compartment of the Case, (*see the Diagram, ante*, p. 227 ;) the small figures in *Lign.* 35, fig. 5, 7, p. 164, may serve to assist the visitor in recognising them. They are labelled, "*Streptospondylus recentior Ow.*"[2] These vertebræ are thus described in my "Geology of

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[1] If the discrepancy in the relative proportions and configuration of the cervical, dorsal, and caudal vertebræ, be regarded as presenting objections to this view, let it be remembered that in the spinal column of our domestic Mammalia an equal dissimilarity prevails; for example, in the Ox, in which the cervical are convex anteriorly, and the convexity gradually disappears in the posterior regions of the spine; and the bodies of the distal caudals, instead of being solid throughout as in the anterior vertebræ, have a large medullary cavity in the centre, as in the fossil reptile, called *Poikilopleuron*, (*ante*, p. 166) Even in the typical form of the genus *Streptospondylus*, the same disappearance of the convexo-concave character in the middle and posterior dorsals, takes place. See Cuvier's "Oss. Foss.," tome v. p. 156.

[2] These vertebræ are described under another name, (*S. major*, nob.) together with others from the oolite of Wilts, which unquestionably belong to the genus Streptospondylus,) in "Brit. Assoc. Reports," 1841, p. 88. These vertebræ have therefore now *two* specific names, one of which must be abandoned; and are referred to a genus, to which at present their claim is at least very doubtful. "*The coining of names for things glanced at and imperfectly understood,—the fabrication of signs without due comprehension of the thing signified,—becomes a hindrance instead of a furtherance of true knowledge.*" Quoted from Professor Owen on Mr. Bowerbank's Pterodactyle, Dixon's Fossils, p. 404.

In Cuvier's "*Oss. Foss.*" (tome v.) there are figures of the convexo-concave type from Honfleur. A model of the British oolitic specimen may be obtained of Mr. Tennant, 149, Strand.

the South-East of England" :—"The vertebræ of the fourth system are very rare; they are of the true lacertian type, having the articular facets of the body convex posteriorly and concave anteriorly, and are wider than high, as in the Iguanas and Monitors, and not in the reverse proportion, as in the existing Crocodiles. In two large but mutilated cervicals, the admeasurements are as follow :—

Height of the concave extremity	3½ inches.
Width of the same	4½ „
Length of the body	6 „

"It is not obvious whether the annular part be united by suture or otherwise; the articular apophyses are horizontal and very strong, the spinous process is destroyed."[1] In the same work, (p. 307) when referring provisionally the "somewhat angular dorsal and caudal vertebræ" to the Iguanodon, I mention "that the above cervical vertebræ correspond so entirely with those of the Iguana and Monitor, that it would seem a more probable conclusion that they belonged to this herbivorous reptile: yet the extreme rarity of this type renders it questionable, since there appears no reason why the vertebræ should not have been found in as considerable numbers as the teeth." On this statement Professor Owen remarks,—"It is the fortunate preservation of the two articular or oblique processes at one of the extremities of the annular part of this fine vertebra, now in the Mantellian Collection, Brit. Mus. No. $\frac{116}{2116}$, that has enabled me to correct the error into which the Founder of that noble collection has in this instance fallen. The flat oblong articular surface of each of the strong and well-marked oblique processes looks downwards and outwards, thus determining them to be the *posterior* pair; and they overhang the concave extremity of the body of the vertebra, showing that to be the *posterior* part. The opposite, or *anterior* end of the body of the same fossil is convex. The few other large convexo-concave vertebræ from the Wealden of Tilgate correspond with the one here described in these important characters of the genus Streptospondylus, and equally differ from the vertebræ of the *Iguanæ*, *Monitors*, and all existing *Sauria*. Of the fossil cervical vertebra six

[1] "Geology of the S.E. of England," 1833, p. 300.

inches long, the anterior part of the body is further indicated by the position of the costal tubercle, or transverse process, which is developed as a strong obtuse ridge from the middle part of that half of the centrum which is nearest the convex articulation."[1]

In the Memoir in the "Philos. Trans." 1849, p. 286, Professor Melville enters at length on the reasons assigned by Professor Owen for referring the above vertebræ to the crocodilian genus Streptospondylus; the following summary will suffice for our purpose; the British student in fossil Erpetology, (when such an aspirant for scientific distinction shall arise), I would refer to the original memoir.[2]

"The large cervical vertebræ from the Wealden strata, with reversed convexo-concave joints, (*Streptospondylus major* of Professor Owen,) enter into the composition of the cervical region of the spinal column of the Iguanodon. We are led to this conclusion by the following considerations:—

"1stly, An anterior dorsal vertebra (in Dr. Mantell's cabinet) from the same deposits, with similar but less marked deviations in the form of the articular facets, and with a configuration of the neural arch, so far as it is perfect, identical with that existing in more posterior dorsal vertebræ with plano-concave joints, well-recognized as belonging to this great herbivorous reptile, links together these apparently discrepant vertebral types.

2ndly, The amount of variation here assumed is parallel to that which exists in its affine among the Crocodilidæ, the *Steneosaurus rostro-minor*[3]; and similar changes in the form of corresponding articular facets occur in the spinal column of the Ruminants, Solipeds, and other Pachyderms;

3rdly, Other alterations in the sculpturing of the neural arch of equal value with the modifications in the form of the articular aspects of the body, are concomitant with these changes in the different vertebræ just mentioned, and are equalled in kind and degree by those which occur in the series of neural arches of the spine in the recent Crocodiles;

4thly, These convexo-concave cervical vertebræ are found

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1 "Brit. Assoc. Reports," 1841, p. 92.
2 "Philos. Trans." 1849.
3 Vide Cuvier, "Oss. Fossiles," vol. ix. 8vo. edit.

in such collocation with other well-determined bones and vertebræ of the Iguanodon, as to leave no reasonable doubt of their belonging to that animal.

5thly, The number of these vertebræ of different ages and sizes in our collections is such as we might have expected on that supposition; and

6thly, if these be not the cervical vertebræ of the Iguanodon, we have the (assumed) *Streptospondylus major* with nothing but a neck, whilst the Iguanodon, as yet known, is wholly destitute of that region of the spine. Is it not, therefore, more probable that the neck of the so-called Streptospondylus belongs of right to the Iguanodon, especially as the bones of that reptile, tested by the fortunate discovery of the Maidstone specimen, constitute the great majority of the osseous relics from the deposits of the Weald?—in other words, the Iguanodon is the reptile *par excellence* characteristic of the Wealden formation.

"The Streptospondylian form of the body of a vertebra can no more characterize a genus of Reptiles than the amphicœlian or cœlospondylian modifications; each is common to a group of species constituting not only distinct genera and families, but also orders and subclasses. Nay, the Streptospondylian type is not even persistent throughout the elements of the same spinal column; it disappears towards the middle of the dorsal region in the *Steneosaurus rostro-minor*, the best known example of this structure, and that in which it was first recognized by Baron Cuvier. The genus *Streptospondylus* of V. Meyer ought therefore to be abolished, and the residual generic application *Steneosaurus* (G. St. Hilaire) be retained to designate Cuvier's first Gavial of Honfleur. The amphicœlian and procœlian forms are generally continued through the whole length of the vertebral column; the Streptospondylian modification in the last sacral replaces, and in the first caudal is superadded to, the procœlian form of the vertebral bodies characteristic of the living Crocodiles.

"In the Report on British Reptiles much stress is laid on the uniformity in length of the bodies of the same vertebral series in Reptiles; this indeed holds good within certain limits among the less complicated smaller existing Lacertæ, but will lead us into error if rigidly applied to the more highly organized extinct Saurians and Crocodiles. The rela-

tive length of a vertebra must always be taken exclusively of the articular convexity, whether that be in front or behind, as is the practice in stating the absolute length of the spine or of its individual regions. Deterred by the great length of the cervical vertebræ referred to the *Streptospondylus major*, when compared with the shortness of the dorsal or lumbar vertebræ assigned by him to the *Cetiosaurus brevis*, Professor Owen was unwilling to associate them together as belonging to the spinal column of the same species of reptile, which, however, appears to be really the case, as I shall afterwards have occasion to demonstrate."[1]

If Professor Owen's opinion be correct, and the bones in question belong to the *Streptospondylus*, then the vertebræ composing the neck of the Iguanodon are at present unknown.

The only specimen that appears to me to afford conclusive evidence on this question is in the possession of J. S. Bowerbank, Esq. F.R.S., and consists of a considerable portion of the spinal column of a very young Iguanodon, imbedded in calciferous grit. Found with this fossil, but detached from it, and without any indication of its connexion with the spine, to which, I believe, it unquestionably belongs, is a series of three cervical vertebræ, which, with his characteristic liberality, Mr. Bowerbank allowed me to figure in illustration of my fourth Memoir on the Iguanodon, in "Philos. Trans.," 1849. Pl. XXIX. fig. 9.

These vertebræ are especially instructive because they demonstrate the true characters of the bones of the neck in a very young Iguanodon; for it is to this reptile this vertebral column must be ascribed. Unfortunately, the bodies of the vertebræ have been crushed and compressed almost flat laterally, and the natural form of the inferior part of the centrum is destroyed, the visceral aspect presenting a sharp ridge, and thus assuming a different contour to that of an adult cervical in my cabinet, which has been compressed in an opposite direction. Nevertheless, the close analogy between these vertebræ is sufficiently obvious; the structure of

[1] In confirmation of the remarks of Professor Melville, I may add that among the large convexo-concave saurian vertebræ recently obtained from the strata of Tilgate Forest, are cervicals and dorsals, belonging to *two*, if not *three*, distinct generic types.

the neural arch is identical; and the only essential difference between the bodies of the respective vertebræ is, that the anterior articulating facet is less convex in the young reptile than in the adult; but as the posterior articular end of the centrum is deeply concave, it is probable that in the recent state the anterior facet possessed a cartilaginous convex epiphysis, by which the ball-and-socket joint was completed: as in the skeleton of the young *Gavial* the facets of the sacro-coccygeal vertebra are flat, though very convex in the adult; (*ante*, p. 167.) so in the Iguanodon, the ball and socket of the cervicals may not have been fully developed and ossified till the reptile arrived at maturity.

The detached neural arch of a small cervical vertebra on the shelf on the extreme left of *Wall-case C*, merits notice, because I submitted it to the examination of Baron Cuvier in 1830, who expressed his belief that it was the *axis* of a young Iguanodon. The bone was then imbedded in a block of Tilgate grit, and the cast of the spinal canal in calcareous spar was visible, resembling the prolongation of the medulla oblongata: the surrounding stone has since been removed, and the fossil proves to be the neural arch of a cervical vertebra—probably, of a crocodilian reptile.

Dorsal Vertebræ.—*Wall-case C, lowest compartment.*—As the anterior dorsal vertebræ have not been found in juxtaposition with other known parts of the skeleton, our knowledge of this region of the spinal column is scarcely more definite than that of the cervical. A large convexo-concave anterior dorsal in my possession, is figured and described by Dr. Melville ("*Philos. Trans.*," 1849, p. 284, Pl. XXVIII.) as a vertebra of the Iguanodon; and if that accurate observer's reference of the cervicals proves to be correct, there can be no doubt that the dorsal in question belongs to a reptile of the same genus. Although there are no vertebræ of this type in the Museum, yet the following notes may be useful to the anatomical inquirer:—

"The anterior convexity is much less than in the cervical, and the posterior concavity shallower; the section of the body would present a deep triangular outline, with the apex below, corresponding to a thick median crest. The body is contracted in the centre, so that the sides are concave parallel to its axis, but convex vertically, owing to the great

prominence of a broad longitudinal ridge, equivalent to that bearing the parapophysial surface in the cervical, above and below which there is a deep concavity. The spinal canal has a transversely oval outline, and enlarges considerably towards each extremity. The length of the body is $4\frac{1}{4}$ inches.

The median dorsal vertebræ are typical of the Iguanodon, several having been found connected with the extremities and other parts of the skeleton. There is a fine example (Mantellian collection, 2160) on the lower shelf to the left of the group of caudal vertebræ (see *Diagram*, p. 227); but I have several larger and more perfect than any in the British Museum.

The centrum has the sides smooth, concave in their antero-posterior diameter, and slightly convex in the opposite or vertical direction; the articular faces are nearly flat, or slightly concave; in some examples they are flat in front, and depressed behind; of an oval form vertically, and flattened laterally; the sides of the centrum converge towards each other below, so as to impart a wedge-like shape to the inferior part in a vertical section. The suture uniting the body to the neurapophysis is almost obliterated in the adult state. The neural arch rises into a broad expansion, or platform, which is supported on each side by a strong buttress, or pillar, that springs from the hinder and outer angle of the base of the neurapophysis. The spinous process rises from the entire median width of the neural platform, contracts as it ascends, and inclines gently backwards.

The articulating depression for the head of the rib is of an elliptical form, and is situated on the side of the neural arch; in the anterior dorsals it is placed on the centrum.

The anterior oblique processes are oval, and face each other; their upper margins are four inches apart: but their inferior ones are separated only by a slight notch in front of the spinous process; they extend but little from the neural platform. The hinder oblique processes are sent off from the under and back part, and overhang the posterior surface of the centrum; their articulating facets are turned downwards, and outwards. The upper transverse process is very strong, and of a trihedral form; it is directed upwards and outwards, with an inclination backwards from the sides of the neural platform, and is supported by a diagonal buttress, or

ridge, which passes outwards from beneath, and is gradually blended with the process. The spinal canal is nearly circular, and expands slightly in front, where it assumes a transversely oval outline. The following are the dimensions of the vertebra above described :—

Antero-posterior length of the body	5	inches.
Transverse diameter of anterior face	5	„
Vertical diameter of the same	6	„
Height from the base of the centrum to the neural platform	7	„
Height of the spinous process	7	„
Width of spinal canal anteriorly	1½	„

The essential distinctive characters of the dorsal vertebræ of the Iguanodon, as demonstrated by Professor Owen (" Brit. Reports," p. 127), are the strong, broad, and lofty bony platform into which the neural arch expands, with its supporting buttresses ; and the presence of a lower transverse process (*parapophysis*) for the reception of the head of the rib, either on the side of the centrum, as in the anterior dorsal vertebræ, or from the side of the neural arch, as in the middle dorsal ; characters which distinguish these vertebræ from those of ophidians, lacertians, and enalosaurians ; while the absence of the posterior convex facet on the centrum, separates them from those of the existing species of crocodilians and lizards.

The usual condition in which dorsal vertebræ are found, is the centrum or body deprived of its neural arch, as in *Lign.* 35, *fig.* 8 (*ante*, p. 164) ; specimens with the upper transverse processes (*diapophysis* of Professor Owen), and the neural arch (as in fig. 6, which is either a posterior dorsal or lumbar), are comparatively rare ; a few vertebræ only have been obtained with the spinous process entire. In the Maidstone specimen, (*ante* p. 146, *Plan* p. 138, *Case* No. 23) there is a series of dorsal vertebræ (some are probably lumbar), but these are so much distorted by compression, that not one presents the normal form, either of the body or the apophyses.

The great strength and expansion of the transverse processes of the posterior dorsals indicate the large development of the abdominal region in this stupendous reptilian vegetable feeder.

RIBS.—*Wall-case C, lowermost compartment.*—There are

many fragments of ribs, and a few with the spinal end entire: the magnificent specimen on the shelf to the right of the group of caudal vertebræ, is the largest example of this part of the Iguanodon that has come under my observation. It was broken into numerous pieces in extracting the block of sandstone in which it was imbedded, and these were chiselled out singly, and connected together, and now form the finest bone of this kind collected in Tilgate Forest; though but a portion of the entire rib, it is forty-six inches in length, and five inches wide at its greatest breadth.[1] The ribs of the Iguanodon have very rarely been found in connexion with the vertebræ; but the two-fold articulation of the costal processes by means of a tubercle and the head, as previously manifested in the structure of the anterior dorsal vertebræ, are characters which enable us to recognize the detached ribs of the gigantic herbivorous saurian. In the anterior ribs the head is large, and of an ovate form; the neck is very long, as may be seen in several of the specimens in the collection, decreases progressively in the middle region of the spine, and finally disappears: the posterior ribs being attached to the ends of the transverse processes. This construction of the costal elements corresponds with that of the crocodiles; in the lizards the attachment of the ribs to the vertebræ is by a single tubercle on the side of the body of the vertebra.

Sacral Vertebræ.—The most important and novel feature in relation to the osteology of the Wealden reptiles enunciated in Professor Owen's Reports, was the remarkable structure of the *Sacrum* in the three extinct genera of Dinosaurians; namely, the Megalosaurus, Hylæosaurus, and Iguanodon; a character first observed in a fine specimen consisting of six vertebræ, with portions of the two iliac bones attached, in the interesting collection of W. D. Saull, Esq. of Aldersgate Street.[2] No one had previously suspected that in these reptiles the pelvic arch was composed of more than two anchylosed vertebræ, as in the living Saurians (*see ante* p. 167), and that the neural arches were transposed from their usual place over the middle of the bodies of the vertebræ, to the ossified intervertebral spaces formed by the anchylosis of the

[1] Several portions of ribs are figured in my "Fossils of Tilgate Forest," Pl. XI.

[2] See "Reports on Brit. Foss. Reptiles," 1842, p. 105.

contiguous bones; the foramina for the transmission of the sacral nerves from the spinal chord, being situated above and behind the middle of the bodies.

Fragments of the pelvic arch, consisting of the centrum of one vertebra, with portions of others anchylosed to the articular ends, are not uncommon; and so long since as 1826, Sir Roderick Murchison transmitted to Baron Cuvier a specimen of this kind, found at Loxwood in Sussex,[1] with several lumbar and caudal vertebræ. Upon these bones M. Cuvier remarked, that the united bodies of the vertebræ "seem to indicate that the animal to which they belonged made such feeble use of its tail that the caudal vertebræ were occasionally anchylosed together."[2] Even the magnificent specimen of the sacrum of the Megalosaurus, consisting of a series of five united vertebræ, figured and described by Dr. Buckland, in 1824, did not suggest the true structure of this part of the skeleton. The announcement of this fact was therefore to me of special interest, since it elucidated the nature of several fossils in my collection that were previously unintelligible.

With the view of acquiring an accurate idea of the vertebræ composing the sacrum of the Iguanodon, I obtained Mr. Saull's permission to have his unique and most instructive specimen completely developed at my own expense, as its characters were in some measure obscured by a layer of hard calcareous grit, with which, as is generally the case in the Isle of Wight Wealden bones, it was partially encrusted.[3]

This Fossil was obtained from the Wealden beds in Sandown Bay, and is strongly impregnated with oxide of iron, and traversed by veins of calcareous spar. It is the sacrum of a young animal, and consists of *six* anchylosed vertebræ (not

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[1] "Geological Transactions," vol. ii. (New Series), p. 105, Plate XV. figs. 4, 6.

[2] On Baron Cuvier's last visit to England, in 1830, I showed him some vertebræ anchylosed in like manner, and on which he made the same remark.

[3] The specimen is figured (for the first time) in Pl. XXVI. of my "Memoir on the Iguanodon, Phil. Trans." 1849. As Mr. Saull, with great liberality, throws his museum open to visitors every Thursday after mid-day, this unique fossil can be seen by any person interested in this department of Palæontology.

of *five* as described in "Brit. Foss. Reptiles," p. 130), with the right iliac bone attached. The relative size and proportions of the several bones composing the sacral arch are now well displayed. The body of the first or anterior vertebra is large, strong, and expanded, forming a powerful buttress in front; the bodies of the two posterior vertebræ are likewise large and strong; but the second, third, and fourth, are constricted laterally in the middle, and are more slender than either the anterior or posterior; by this modification of the elements of the sacral arch, both lightness and strength were obtained.[1] A similar conformation is observable in every specimen of the sacrum that has come under my observation, whether of young and small, or of old and large individuals; in all, the vertebræ have the same relative proportions.[2] The only portion of the sacrum of the Iguanodon in the British Museum, is the detached vertebra placed above the tray containing the femur marked No. 5, in the upper division of Wall-case *C*. (*See diagram, ante*, p. 227. 2.) It evidently belonged to a young individual, for the body has separated from the contiguous bones without fracture.

The Pelvis.—Ilium.—Of the bones of the pelvis, namely the *Ilium*, *Ischium*, and *Pubis*, specimens of the first only have been found in connexion with the sacrum, or associated with other parts of the skeleton. The right and left iliac bones, detached from the pelvic arch, are imbedded near each other, in the Maidstone fossil; and in Mr. Saull's, a considerable portion of the right ilium remains attached in its natural position.[3] Captain Lambart Brickenden has the finest detached example of this element of the pelvis that has

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[1] A detailed anatomical description of this sacrum is given in "Philos. Trans." 1849, pp. 297—299.

[2] Among the water-worn masses of bone strewn along those parts of the southern shores of the Isle of Wight, which are bounded by cliffs of the Wealden strata, I had often met with specimens in which the body of a very large vertebra was anchylosed to one so disproportionately small, that I could not explain their origin, until Professor Owen's description of the structure of the sacrum suggested their true nature. These fossils in fact consist of one of the large bones either of the anterior or posterior end of the sacrum united to one of the slender middle vertebræ.

[3] "Philos. Trans." 1849, Pl. XXVI. A.

come under my observation; it was found imbedded in the friable sandstone of Tilgate Forest, from which it has been successfully extricated.

The ilium of the Iguanodon resembles that of the monitors in its hatchet-like form, and in the prolonged extremity; in the Maidstone specimen one of the iliac bones shows the inner or sacral surface, and the other the outer aspect. The slender prolonged extremity described by Professor Owen as the posterior part, is regarded by Professor Melville as the anterior, and "only an exaggerated condition of the short spine projecting forwards from the ilium in the smaller lacertæ." The discovery of perfect specimens of the bone, or characteristic portions in connexion with the sacrum, will determine this question: that the anterior part of the *sacrum* is that so described by Dr. Melville in the "Philosophical Transactions," is confirmed by the specimens subsequently obtained.

Os Pubis. *Wall-case C, uppermost shelf.* (*Diagram, ante,* p. 227.)—A fragment of a very broad and curved plate of bone, (labelled 2132), 16 inches long, and $9\frac{1}{2}$ wide, and but 3 inches in its greatest thickness, and which required many hours of labour to extricate from the stone in which it was imbedded, is evidently a portion of the pubis of a gigantic saurian; it is, with great probability, ascribed to the Iguanodon by Professor Owen, who thus describes it. "The Pubis, which presents a simple spatulate form in the Crocodiles, already begins to increase in breadth at its symphysial extremity in the extinct family with concave vertebræ; and in the larger existing species of Lizards is expanded at both extremities, and has a very marked and recognisable character superadded, in being bent outwards with a considerable curvature.

"A massive fragment of a broad osseous plate, bearing a segment of a large articular cavity at its thickest margin, and thence extended as a thinner plate, bent with a bold curvature, and terminated by a thick rounded labrum, offers characters of the Lacertian type of the pubis too obvious to be mistaken; and since the modifications of the ilium of the Iguanodon in the Maidstone skeleton approximate to the Lacertian type of the bone, and especially as manifested by the great Varani, in which the recurved character of the pubic plate is most strongly marked, we may with much

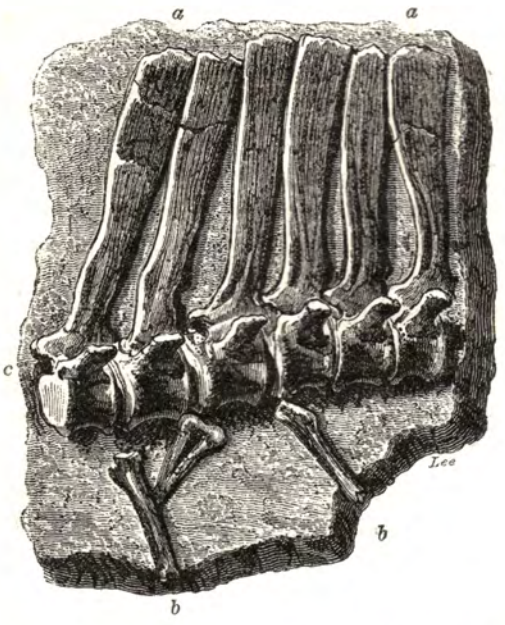
probability, assign the fossil in question to the pelvis of the Iguanodon.

"This fine portion of pubis is of an inequilateral triangular form, 16 inches in its longest diameter, $9\frac{3}{4}$ inches across its base, or broadest part, $6\frac{1}{5}$ inches across its narrowest part. The fractured surface of the bone near the acetabulum, is $3\frac{1}{4}$ inches thick. The acetabular depression is seven inches across, a proportion which corresponds with that of the acetabular concavity in the ilium, and with the size of the cavity in which the head of the Iguanodon's femur must have been received. One angle of the cavity corresponding with the anterior one in the Varanus, is raised; a broad and low obtuse ridge bounds the rest of the free margin of the cavity. The smooth labrum exchanges its character near one of the fractured edges of the bone for a rough surface, which indicates the commencement of the symphysis. In the apparent absence of the perforation below the acetabular depression, the present bone agrees with the Crocodilian type."—*Brit. Assoc. Rep.* 1841, p. 136.

Ischium? *Wall-case C. Upper shelf.*—Near the specimen last described, there is a fragment of a large lamelliform bone, (labelled $\frac{188}{2576}$), which Professor Owen considers to bear most resemblance in its general form and slightly twisted character to the Ischium, with traceable modifications intermediate to those presented by the extinct *Goniopholis*, and modern *Varani* and *Iguanæ*. I had often attempted to discover the true character of this bone when in my possession, but could not arrive at any satisfactory conclusion respecting it; it struck me as more nearly resembling a bone of the arm than of the pelvis, and that it might possibly be the humerus of an unknown species or genus of saurians; its surface and texture differ from those of the bones of the Iguanodon.

Caudal Vertebræ and Hæmapophyses. *Wall-case C, lowest compartment.*—These elements of the spinal column have been discovered from time to time in numerous localities of the Wealden strata; the caudal vertebræ collected by myself, or submitted to my examination, amount to several hundred specimens. The most splendid example beyond comparison is the series of six anterior caudal vertebræ with their processes almost entire, and three chevron-bones or hæmapophyses,

imbedded in a slab of Tilgate grit, that is placed in the middle of the lowest compartment of this Case.



LIGN. 57. SIX CAUDAL VERTEBRÆ OF THE IGUANODON; FROM TILGATE FOREST.

($\frac{1}{16}$ *nat. size.*)

a. a. The spinous processes, from 13 to 15½ inches in height.
b. b. Three displaced *chevron-bones*, or *hæmapophyses*, imbedded in the stone near their original position between the bodies of the vertebræ.
c. Anterior articular face of a vertebra.

The characters of the anterior caudal of a young Iguanodon are beautifully displayed in this invaluable specimen. The bodies of the vertebræ lie in natural juxta-position, the anterior oblique processes embracing the posterior; the spinous processes are entire and in their normal situation, and the transverse but little mutilated. Three displaced chevron-bones are imbedded near the corresponding articular surfaces of the bodies of the vertebræ, the proximal ends of two of them being almost in contact with the intervertebral spaces to which they belonged. The original position of the respective parts will be understood by reference to *Lign.* 35, p. 164, figs. 3, and 3 *a*, which is intended to illustrate the normal characters of the caudal vertebræ of the Iguanodon, and the

relative proportions of the apophyses; the figure is $\frac{1}{6}$ the size of the original.

Fig. 4 of the same lignograph is a lateral view of a caudal vertebra, remarkable for the deep cavity left between the centrum and the base of the neurapophysis, (*o*) by the removal of the pleural element or transverse process, which had dropped out before the bone was imbedded in the sandstone.

In the caudal vertebræ the centrum is more cuneiform than in the dorsals, the sides are smooth and almost flat vertically, and but slightly depressed in their antero-posterior diameter; at their inferior convergence, instead of uniting in a rounded ridge as in the dorsals, they are separated by a deep longitudinal furrow, bounded anteriorly and posteriorly by the oblique extremity of the centrum, which is truncated at both ends to articulate with the inferior spinous process or chevron-bone (see *fig.* 3, *Lign.* 35). The articular faces of the bodies correspond with those of the posterior dorsals; the anterior surface is almost flat, the posterior slightly concave; the neural arch no longer presents the peculiar characters observable in the dorsal and lumbar vertebræ; it is attached by a wide base to the body, and the two laminæ in some instances extend transversely over the latter so as to complete the spinal canal, as in many of the dorsal vertebræ. The anterior zygapophyses (which are shown in *Lign.* 57) have their elliptical articular surfaces almost vertical, and closely embrace the corresponding posterior processes; the latter spring off from the base of the neural spine, and project over the centrum. The *neural spine*, or spinous process, is very long; it rises by an anterior basal ridge from the neural arch as in the dorsals, but is greatly contracted at its commencement, and increasing in breadth as it ascends, terminates in a thick truncated summit. The longest spine in the specimen before us is nearly 16 inches in height, and 2 inches in antero-posterior diameter at the summit; the spine is thin in a transverse direction, the truncated summit is but $\frac{1}{4}$ inch thick. The transverse processes are relatively short and strong. The height from the base of the centrum to the top of the spinous process is 22 inches, and as the chevron-bone, when perfect, would be nearly five inches in length, the vertical expansion of the tail in the young Igua-

nodon to which these vertebræ belonged, must have been at least twenty-seven inches.

CHEVRON-BONE, or *hæmapophyses.*—*Wall-case C, left-hand shelf, lowest compartment.*—The form of this element of the caudal region is well shown in this large and perfect specimen, which is figured in my "Fossils of Tilgate Forest," pl. xii. It is eleven inches in length, and 2 inches in antero-posterior diameter. The two laminæ of which this bone essentially consists, are in the Iguanodon blended at the proximal end into an expanded cuneiform head, which fits into the corresponding intervertebral space left by the truncated angles of two contiguous vertebræ; and the distal portion constitutes a strong solid spine, a wide interspace, forming the canal for the passage of the large blood-vessels of the tail, being left at the upper part (as is shown in *Lign.* 35, fig. 2, 3, and 3 *a, f,* p. 164); this channel is three inches long in the specimen before us. The blending of the proximal articular ends of the hæmapophyses into a single head, is constant throughout the caudal region of the Iguanodon, so far as my knowledge extends; among the hundreds of caudal vertebræ which I have examined, the unity of the hæmapophysial surface is distinctly impressed.[1]

OTHER VERTEBRÆ, *in Wall-case C.*—It would extend this article to an undue length were I to dwell on the anatomical characters of the other vertebræ in this Case, some of which, Dr. Melville and myself believe to be referable to the Iguanodon, while Professor Owen refers them to other genera. On many of these points the evidence appears to me to be insufficient to warrant a positive decision; and it will be most conducive to the successful elucidation of the subject by future inquirers, if, in this place, I subjoin a list of the specimens, with Professor Owen's interpretation of them.

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[1] The figure of a caudal vertebra with two distinct hæmapophysial surfaces, in Professor Owen's Monograph on "Cretaceous Fossil Reptiles," Pl. XXXVII. is certainly not a representation of a normal character: neither is the circular face of the centrum of the dorsal vertebra in Pl. XXXVI.; nor the posterior zygapophysis in Pl. XXXV. In fact, all these parts of the skeleton in the Maidstone specimen are so distorted, that it is impossible an artist can give the true characters of the original bones: especially when seen through the glass case that covers them.

Vertebra marked $\frac{123}{2123}$;[1] body with the bases of the neural arch; figured in my "Fossils of Tilgate Forest," Pl. IX. fig. 11.

" " $\frac{138}{2138}$; body of a dorsal vertebra.

These are assigned to the crocodilian reptile to which the slender, flat, acuminated teeth belong; under the name of *Suchosaurus cultridens.*

A *Caudal Vertebra*—split vertically, the body having a central cavity which is filled with white calcareous spar, $\frac{294}{2294}$, $\frac{295}{2295}$. Referred to the *Poikilopleuron;* a crocodilian reptile found at Caen. Neural arch of an anterior dorsal vertebra $\frac{141}{2141}$: figured in "Fossils of Tilgate Forest," Pl. XII. fig. 1, is also provisionally referred to the same genus.

Two convexo-concave cervical vertebræ $\frac{116}{2116}$; referred to *Strepto spondylus major* in "Brit. Assoc. Rep.," and now labelled *S. recentior,* in all probability belong to the Iguanodon.

Posterior caudal vertebræ 2112, 2142, 2153; referred to *Cetiosaurus brevis.*

Large posterior dorsal $\frac{133}{2133}$.

" " " eight inches in diameter $\frac{115}{2115}$; these are also referred to *Cetiosaurus brevis.*

Four perfect anterior caudals. These are also assigned to *Cetiosaurus brevis;* described provisionally by Dr. Melville as *C. Conybeari,* and since referred by me to the genus *Pelorosaurus,* to be described hereafter.

Two elongated subangular bodies of posterior caudals, figured in "Fossils of Tilgate Forest," Pl. IX. fig. 8, and Pl. X. fig. 1; assigned to *Cetiosaurus brevis:* referred to Iguanodon by Dr. Melville. The last reference, which appears to me the most probable, must, however, be regarded as only conditional.

Dorsal vertebra $\frac{109}{2109}$; assigned to *Cetiosaurus brachyurus.*

Caudal vertebra $\frac{161}{2161}$; to the same, referred by Dr. Melville to Iguanodon.

Dorsal vertebra $\frac{160}{2160}$ and $\frac{556}{2556}$; referred to Iguanodon.

Caudal vertebra $\frac{130}{2130}$; referred to the Iguanodon.

Sacral vertebra $\frac{127}{2127}$; to the same.

All the specimens above enumerated are described in "Reports on Brit. Foss.," with that minuteness of detail and consummate skill, which characterise the anatomical investigations of the Hunterian Professor.

The following extract from Professor Melville's commentary on the above generic and specific determinations will put the scientific inquirer in possession of the opinions of that eminent anatomist on the questionable references:—"I can perceive no difference between the posterior dorsal or lumbar vertebræ (No. 2,133, 2,115) assigned by Professor Owen

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[1] The numbers refer to those affixed to the specimens in the "Catalogue of the Mantellian Collection in the British Museum."

to the *Cetiosaurus brevis*, and that last described as corresponding in some respects to the fifth dorsal in the spinal column of the Crocodile, than a diminution in the relief of the buttress supporting the transverse process. In No. 2,115 the neural arch is broken away, and the tract of the centrum left uncovered behind to form the floor of the intervertebral foramen, is of greater extent than in No. 2,133, indicating a more posterior situation in the vertebral series. The approach to the quadrangular form of the body of this vertebra is no proof whatever of a specific and still less of a generic distinction; otherwise the first sacral vertebra, which is more decidedly quadrate, if found separate, would be equally entitled to a generic value; but its association, in the sacrum from Mr. Saull's collection, with other vertebral bodies of a very dissimilar character, and with the ilium of the Iguanodon, prevents our falling into an error of such magnitude. We may therefore reasonably conclude, that these vertebræ, to wit, Nos. 2,133, 2,115, belong to the Iguanodon, and that No. 2,115, in the form of the body, approached the first sacral, and was one of the proper lumbar series.

"The vertebra, No. 2,109, attributed in the above-mentioned report to the (so-called) second species of Cetiosaurus found in the Wealden formation (*C. brachyurus*), is also a posterior dorsal or lumbar vertebra of the Iguanodon; the neural arch is much mutilated. The only other element of the skeleton of that species is a caudal vertebra, No. 2,161, which also belongs to the Iguanodon; being in fact one of the most anterior of the caudal series, and contrary to the character of the genus to which it was referred, it presents one of the most interesting and instructive examples of the rough surface on the sides of the upper aspect of the centrum, left by the removal of the unanchylosed neural arch. The so-called *Cetiosaurus brevis* being thus founded only on two vertebræ which belong to the Iguanodon, must be expunged from the list of extinct reptiles.

"The angular posterior caudal vertebræ referred in the Report on British Reptiles, to the *Cetiosaurus brevis*, I am also inclined to assign to the Iguanodon for the following reasons:—1stly, a similar vertebra, as far as can be ascertained, exists in the Maidstone specimen, and in this case an admixture of bones of distinct animals can scarcely be suspected; 2dly, the numerical ratio of the vertebræ of this kind occurring in the Wealden, to those from the same deposits and localities belonging to other regions of the spinal column, all referable to the Iguanodon, excepting the few megalosaurian and crocodilian vertebræ, is such as long ago to have induced Dr. Mantell to regard them as characteristic of that saurian; and the occurrence of such vertebræ with those of the sacrum and other bones of the Iguanodon in Western Sussex, described by Cuvier, has already been commented on:[1]—3dly,

[1] In reference to the somewhat angular caudals, alluded to in the text, I would remark that with the unquestionable sacral vertebræ of the Iguanodon found at Loxwood, and transmitted to Baron Cuvier by Sir Roderick Murchison, (*ante*, p. 269,) there were several that appeared to belong to the same individual, which possessed the angular form and sulcated base of the bones described in the text, as may be seen by

as the four large anterior caudal vertebræ in the Mantellian Collection, also assigned by the author of the Report to the *Cetiosaurus brevis*, cannot be transmuted into the vertebræ in question by any changes occurring in a consecutive series, there is left for that animal only some terminal caudal vertebræ; while to complete the tail of the Iguanodon just those are wanting; 4thly, but independently of the evidence furnished by the Maidstone specimen, we have seen examples which point out the series of changes by which these angular vertebræ are produced from those of the middle caudal region. These changes, again, are not greater than those that take place in the tail of the Hylæosaurus, and other extinct reptiles, as well as in that of many mammalia.

"Let us look for a moment at the vertebræ of the tail of the Mosasaurus as contrasted with those of other regions of the spinal column in that reptile, and we shall then be prepared to admit far greater modifications than are here assumed. Could we *à priori* correctly restore the vertebral column of any animal from scattered fragments, belonging to different individuals, without making any allowance for the changes occurring in the series of segments composing that column?

"In the form of the terminal caudal vertebræ we may expect to find a very great similarity even in remote genera, and hence it is unsafe to base a generic character on their peculiarities. The genus Cetiosaurus (restricted to the species *medius* and *longus* from the Oolite) is founded chiefly on such trivial distinctions, and we may refer to it any caudal vertebra of considerable dimensions with plano-concave or biconcave facets, not referable to other known and perfectly determinate genera,

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a reference to the "Geol. Trans." vol. ii. New Series, Pl. XV. figs. 1, 3. The figures were drawn by Mr. Scharf, and I can vouch for their accuracy; but without the actual connexion of vertebræ with such character, with known parts of the skeleton, I should not consider this opinion decisive. H. von Meyer has justly remarked, "that conclusions drawn from a single part of a fossil skeleton, and applied to the whole, must necessarily prove erroneous, and have deceived even such anatomists as Camper. While we remain ignorant of the plan according to which the structure of the whole animal is formed, but little can be deduced from the single parts. A fossil saurian, with an elongated beak, like that of a Gavial, is not necessarily from that circumstance alone, a Gavial, a creature for which it has commonly been taken; the other portions of the skeleton may be totally different from this latter animal. How little we can infer from one fossil saurian as to the structure of another, is shown by the Megalosaurus and Geosaurus, the teeth of which are very similar, while they have nothing else in common. In the apparatus of the teeth of the fossil saurians, which we have to consider, there is usually expressed a combination of the characters of the crocodile with those of the lacertæ; to which are occasionally added peculiarities which remind us of the apparatus of the teeth of fish, of cetacea, and even of the land mammalia, both herbivorous and carnivorous."—"*Palæologica. Geschichte der Erde und ihrer Geschöpfe; Hermann von Meyer.*" *Frankfort*, 1832.

such as the Ichthyosaurus and Plesiosaurus, of which we have fortunately nearly perfect skeletons, and hence cannot be led astray in the labyrinth of fragments from which we are compelled, in most instances, to construct the lost denizens of the former lands and seas of our globe."[1]

PECTORAL ARCH OF THE IGUANODON.—In the lacertian reptiles the construction of the pectoral arch is much more complicated than in the Crocodiles. The sternum is a long, narrow, and depressed bone, that gives out two lateral branches, and between which its point sometimes passes and proceeds more in front under the neck. There is also a still greater difference, in the development of the *coracoid*, and in the constant presence of a *clavicle*. The coracoid furnishes nearly one half of the glenoid cavity, or socket for the head of the humerus, and gives out one or more apophyses to support a large cartilaginous arch which passes over the narrow bone in front of the sternum, and crosses that of the coracoid on the other side. There is always a foramen for the vessels, pierced in the neck of the bone, between its apophyses and the glenoid facet. The scapula or omoplate forms the other portion of the glenoid cavity; in the middle, or about one third of its length, the osseous part suddenly terminates, and is continued by a cartilaginous portion: this frequently becomes ossified, and then the scapula is constantly divided into two bones.[2]

The dismembered state in which even the more strongly connected bones of the skeleton occur in the Wealden deposits, rendered it very unlikely that the elements of the pectoral arch should be found in such contiguity as to exhibit the construction of this important part of the fabric; and it is only within the last three years that I have obtained data by which the restoration of its structure could be attempted. The slender and complicated bone that enters into the composition of the pectoral arch of the Iguanodon, the *Clavicle*, was obtained entire before the lamented death of the illustrious Cuvier; yet this bone, like the teeth, was so anomalous in its characters, as to render its interpretation very difficult.

CLAVICLE OF THE IGUANODON. — *Wall-case C, lowest compartment.* (*ante*, p. 227.)—The clavicle in the Iguanas and

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[1] "Philos. Trans.," 1849; pp. 293, 294.

[2] Cuvier's "*Règne Animal.*"

Monitors is a slender, gently curved, bone, stretching from the scapula to the sternum, and attached to each by a simple extremity; but in others of the lacertians the median or pectoral end is more complicated, and in some respects resembles the clavicle which I have ascribed to the Iguanodon.

None of the isolated bones of the Iguanodon occasioned me more perplexity than this element of the pectoral arch, especially as a fragment of the mesial extremity was for a long while the only portion obtained. Even when the perfect bone in the Case before us was discovered, it was very embarrassing to determine to what part of the skeleton it belonged. Baron Cuvier, to whom I sent a sketch of the fossil, thought at first it was a fibula, and afterwards that it might be a clavicle; but if it were, it did not resemble that of a reptile, nor, indeed, of any other living creature. Upon taking it to the Hunterian Museum, Mr. Clift could discover no bone at all resembling it, excepting the first rib of an Ostrich, which has processes bearing a distant resemblance to the apophyses observable at the pectoral extremity.

In the "Geol. S.E. of England," this bone is figured (Plate IV.) and described, with the remark that the only place in the skeleton it could be referred to, was either the thorax or the lower extremities: "it may be a fibula, a rib, or a clavicle; and that it is a clavicle of some extraordinary extinct reptile is the most probable supposition."

In 1841, when labouring under a severe indisposition from which recovery was thought hopeless, I communicated to the Royal Society a few notes on the reptilian remains I had collected, with a view to assist future observers, and at the same time I presented to Professor Owen the drawings of all my principal specimens, which I had prepared with a view to publication; for I was anxious that the labour I had bestowed upon this investigation might be made available to science.[1] In that Memoir, the bone in question is thus described:— "Several bones evidently referable to a complicated sternal apparatus, and approximating to that of the Lizards, were discovered many years since; and one of these of a very extraordinary form was figured and described in "Foss. Tilg.

[1] Appendix G. Drawings of remains of Fossil Reptiles from Tilgate Forest.

For." and "Geol. S.E. of England," under the provisional name of *Clavicle.*

"This bone is long, slender, slightly arched, of a prismatic form in the middle, and enlarged and flat at both extremities. At the distance of not quite one-third from the widest (sternal) extremity, a small apophysis is sent off, and the bone then enlarges and terminates in two unequal flat processes. A perfect specimen is 29 inches long, and $3\frac{1}{2}$ inches wide at the expanded sternal end; and there are portions of others, indicating a total length of 3 feet. In the Maidstone Iguanodon there are two bones of this kind in a mutilated state. In none of the skeletons of reptiles, nor indeed of any other animals to which I have had access, are there any bones with which the fossils can be identified. Mr. Owen pointed out to me a bone attached to the coracoid and omoplate of a small lizard that bore some analogy to the fossil;[1] and I have no doubt that a more extended anatomical investigation will ere long afford a solution of the question. It is satisfactory to find that the correctness of my first appropriation of this bone to the Iguanodon many years before it was found in connexion with any part of the skeleton, has been confirmed by subsequent discoveries. Doubtful, however, whether this bone should be regarded as a clavicle, I propose to distinguish it by a distinct name, *Os Cuvieri*, till future discoveries demonstrate whether it is a new element superadded to the pectoral arch of the colossal herbivorous saurian whose structure is in other respects so anomalous, or a true clavicle."[2] Subsequent discoveries have established the correctness of my original conclusion.

CORACOID OF THE IGUANODON. *Wall-case C, uppermost shelf.* (*ante*, p. 227.)—"A coracoid bone, ten inches wide, was found imbedded in a block of Tilgate grit with bones of the Iguanodon. It resembles in its hatchet-like form the corresponding bone in the lacertians, and its articulating surface furnishes, as in that family, one-half of the glenoid cavity for the reception of the head of the humerus; but its margin is entire, and not

[1] "The bone attached to the coracoid and omoplate of a small lizard which I pointed out to Dr. Mantell as resembling the one in question, was the clavicle of *Cyclodus nigroluteus.*"—*Prof. Owen in Brit. Assoc. Report, p.* 136.

[2] "Philos. Trans." 1841, p. 137.

produced into one or more apophyses as in the Monitors, Iguanas, &c.; and instead of a perforation in the neck of the bone for the passage of vessels, there is a deep fissure or notch, separating the glenoid cavity from the scapular facet."[1] A reduced figure of a coracoid of this kind is given in *Lign.* 58. In the collection, there are portions of other coracoids of the same character.

LIGN. 58. 1. CORACOID: 2. SCAPULA; OF THE IGUANODON. TILGATE FOREST. ($\frac{1}{6}$ *nat. size.*)

SCAPULA OF AN UNKNOWN REPTILE.—*Wall-case C.*—Over the above specimen, there is a very remarkable bone which it will be convenient to notice in this place. It is thus described in my Memoir, "Philos. Trans." 1841:—"A scapula or omoplate eighteen inches long, associated with bones and teeth of the Iguanodon, and probably referable to that animal, presents, like the coracoid, some important modifications of the usual lacertian type. This bone is very thin and flat, and of an elongated form; it differs considerably from the omoplate of the Monitors and Iguanas. It somewhat resembles the scapula of the Scincs, and it throws off a long tripartite apophysis (*a*, *b*,) which is imperfect in the only specimen hitherto discovered; this process probably afforded support to a cartilaginous arch as in the existing lizards.

"But although, from circumstances which it is unnecessary

[1] From my Memoir in "Philos. Trans." 1841. The reader will please to remember that at this period Professor Owen had not entered on this department of Palæontology, which he has since so greatly advanced by his anatomical knowledge and indefatigable labours.

to detail, I entertain but little doubt that the coracoid and omoplate above described belong to the Iguanodon, it is so hazardous in palæontological inquiries to affirm as certain what is merely probable, and so many impediments to accurate inductions have been occasioned by hasty and positive determination of a tooth or bone from imperfect analogies, that I deem it necessary to repeat, that these specimens were not found in juxta-position with other parts of the skeleton of the Iguanodon, but merely imbedded in the same mass of stone."—*Philos. Trans.* 1841.[1]

LIGN. 59.
SCAPULA OF AN UNKNOWN SAURIAN; FROM TILGATE FOREST.
($\frac{1}{18}$ *nat. size.*)

SCAPULA OF THE IGUANODON. *Lign.* 58.—The prudence of the above reservation was shortly demonstrated by the discovery of a scapula of a very different type, of which a reduced sketch is given in *Lign.* 58, and which unquestionably belongs to the Iguanodon: the scapula above described must therefore be referred to some other genus of the Wealden reptiles; it may possibly belong to the Megalo-

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[1] Professor Owen in "Reports on Brit. Foss. Rept." offers the following remarks on this unique and peculiar scapula:—

"The scapula has not hitherto been discovered so associated with other unequivocal portions of the skeleton of the Iguanodon as to permit the characteristics of this bone to be confidently recognised. The bone, (No. 194, *Omoplate* of Iguanodon, *Mantellian Catalogue*,) agrees with the undoubted scapula of the Hylæosaurus, and with that of certain lacertians, especially of the genus *Scincus*, (Dr. Mantell has pointed out this resemblance in his Memoir in the 'Phil. Trans.' 1841,) in the production of a long slender pointed process, continued at nearly right angles with the body of the bone, from the anterior part of the articular surface for the coracoid; but it differs from the scapula of the Hylæosaurus in the presence of two short processes given off from the lower part of the base of the long process, and in the absence of the thick and strong transverse acromial ridge which overarches the glenoid depression, and in the deeper concavity of the posterior margin of the ascending plate or body of the bone. This part, in its shape and relation, length and breadth, is intermediate between the crocodilian and lacertian type of the scapula, at least as exemplified in the monitors and iguanas, where it is broad and short. The *Scincs* and *Chameleons*, in the more crocodilian proportions of their scapulæ, resemble the Hylæosaurus, and the great species of extinct saurian, most probably the Iguanodon, to which the present bone belongs."—*Brit. Ass. Rep.* p. 134.

saurus, in which the coracoid ("Geol. Trans." vol. vi. pl. xliii. fig. 3) is of a more complicated structure than in the Iguanodon and Hylæosaurus, and somewhat resembles that of the Iguanas or Varanians.

"I had often vainly attempted to find such a correspondence between the articulating facets of the coracoid and scapula above mentioned, as would warrant the conclusion that they originally belonged to the same genus of saurians. By the fortunate discovery of a perfect Scapula which fulfils these conditions, and can also be shown to belong to the Iguanodon, both the bones forming the scapular arch are now for the first time demonstrated.

"This specimen is represented $\frac{1}{4}$ the natural size in 'Philos. Trans.' 1849, pl. xxx. fig. 10; when obtained it was firmly imbedded in the hard Tilgate sandstone, and broken into several pieces: I succeeded in extricating the whole from the rock, and in reuniting the dissevered parts, so as to demonstrate the perfect form of this most interesting fossil. It is the right scapula, and is 13 inches long, $5\frac{1}{4}$ inches wide at the humeral, and 4 at the upper or spinal extremity; like that of the Crocodile, it is slender, flat, and slightly arched; at the humeral end it is thick, and expands to form the apophysial surface that united with the coracoid, and the outer half of the glenoid cavity to receive the head of the humerus; it is flat and thin at the upper or distal end. This bone differs essentially from the scapula of the Iguanas, Monitors, &c., and approximates to that of the Crocodiles and Scincs; the minute scapula of the Chameleons presents the same simple characters.

"Upon placing this Scapula in juxtaposition with the Coracoid above assigned to the Iguanodon, it will be manifest that the two bones must have belonged to the same scapular arch; as is shown in *Lign.* 58. The close resemblance between this form of pectoral arch and that of the Hylæosaurus will be seen at a glance by reference to the latter. The Scapula of the Iguanodon differs from that of the Hylæosaurus in having the body more arched and slender, and the neck more contracted; and in the absence of the strong acromial ridge which characterises the latter. The Coracoid differs chiefly in its greater external convexity, and inner concavity, and in the apophysial scapular surface being separated

from the glenoid facet by a deep notch for the passage of vessels, instead of having a simple perforation as in the Hylæosaurus. In both these reptiles, however, there is a general analogy in the structure of the pectoral arch."[1]

"While examining the above Coracoid and Scapula I was reminded of the fractured portion of two long flat bones in the Maidstone specimen, (see *Lign.* 65,) which had hitherto remained perfectly unintelligible; and upon repairing to the British Museum, the analogy between these mutilated bones and the scapula was apparent, but it required much careful examination and comparison before their identity could be satisfactorily determined. The fragments in the Maidstone fossil are, I think, unquestionably the remains of the left and right scapulæ, which when perfect were of the type above described.

"As the clavicles, coracoids, and scapulæ, are now determined, the structure of the pectoral arch of the Iguanodon may be regarded as established; and although the sternum is at present unknown, and the relative positions of the several parts can only be conjectured, I have ventured to attempt the restoration of this important part of the skeleton."[2]

HUMERUS OF THE IGUANODON.—*Wall-case C, lowest compartment on the right.* (*ante*, p. 227.)—Although numerous femora, tibiæ, and other bones of the hinder extremities were early discovered by me in many localities in Sussex, and the Isle of Wight, no certain remains of the fore-limbs, except the metacarpals, were recognised until the summer of 1848. In the "Report on British Fossil Reptiles," Professor Owen[3] sug-

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[1] "Philos. Trans." 1849, p. 278.

[2] See my Memoir communicated to the Royal Society, and published in "Philos. Trans." 1849, p. 279, in which a restored figure is given of the pectoral arch of the Iguanodon.

[3] "*Humerus.*—This important bone has not been hitherto satisfactorily determined; it differs less from the femur in form in Reptiles than in Mammalia. In the modern Crocodile the chief distinction in the form of the humerus is the ridge at the upper third of the bone; in Lizards this distinction is almost lost. If we find the femur of the Iguanodon distinguished from that of all other reptiles by the *presence of a peculiar process from the inner side of the bone, there are not wanting grounds to expect that the humerus may present a similar character.* As the reasons for suspecting that some of the large bones, hitherto uniformly regarded as the *femora*, may be the *humeri* of the *Iguanodon*, will best appear in the description of the femur, I shall now

gested that some of the bones in the British Museum which I had regarded as femora, were in all probability humeri, and the observations of a correspondent are quoted by him in corroboration of this opinion; but no one who had given due attention to the subject, would for a moment admit the validity of the reasons adduced by the Hunterian Professor.

LIGN. 60.
HUMERUS OF THE IGUANODON; POSTERIOR ASPECT.
($\frac{1}{10}$ *nat. size.*)

The question, however, is now decided by the discovery of a bone in the Wealden of the Isle of Wight, associated with other remains of the Iguanodon, which is undoubtedly a humerus, and possesses all the essential characters of the principal bone of the anterior extremity of a gigantic saurian; most fortunately, too, it can be proved to belong to the Iguanodon; for it is identical with a well-preserved, but much distorted and smaller bone, in the Maidstone specimen, which is figured in my Memoir in "Philos. Trans." 1841,[1] with the remark that "it probably belongs to the brachial extremity; it is imbedded near the two metacarpals, but I have not been able to determine its character satisfactorily." The relatively very small size of this bone appeared to me an insuperable objection to the regarding it as a humerus, and I thought it more probable that it belonged to the fore-arm, and was possibly the radius. In the

proceed to the consideration of the large bones with which the femur is articulated."—*Prof. Owen, Brit. Assoc. Reports*, p. 135.

The reader will perceive how completely the Hunterian Professor was at fault; and that the attempt to show that my interpretation of the colossal bones in the Case before us was erroneous, utterly failed.

[1] "Philos. Trans." Pl. VIII. fig. 5.

"Reports on British Fossil Reptiles," Professor Owen states that this bone corresponds with certain bones of the foot found at Horsham;[1] but both extremities of the fossil in question entirely differ from the articulating surfaces of all the metacarpals and metatarsals of the Iguanodon that have come under my observation; a comparison with the humerus from the Isle of Wight will at once establish its true relations.

This bone was obtained from the Wealden deposits on the southern shore of the island, by Mr. Fowlstone, to whom I am indebted for permission to have a cast taken of it: it is figured in *Lign.* 60. It is perfect, with the exception of the outer tuberosity of the head; its dimensions are as follow:—

Greatest length	3 feet.
Length in a straight line from the inner tubercle of the head to the inner condyle	31½ inches.
From the outer tubercle of the head to the external condyle	33 ,,
Circumference of the head	23½ ,,
——— round the condyles	21½ ,,
Circumference of the shaft at the deltoid crest	19½ ,,
——— one-third from the distal extremity	16½ ,,

The medullary cavity only extends to within one-third of the top of the bone; it is three inches in diameter: the greatest thickness of the wall of the shaft is one inch.

The head of the bone presents the usual posterior protuberance of the humerus in Lizards, but the epiphysis of this, as well as of the distal extremity, is wanting, as is the case in all the long bones of the Wealden reptiles. At about three inches from the top, the ridge or crest for the insertion of the deltoid muscle is considerably developed, and extends fifteen inches down the shaft, which rapidly contracts below, and finally expands to form the condyloid extremity. The articular face of the latter is divided into two nearly equal condyles; the inner or ulnar segment is traversed by an anterior furrow, which is more strongly marked in the humerus of a younger individual in my cabinet; the posterior or olecranal

[1] "The bone of the Maidstone Iguanodon (marked 7 in the figure above cited in the 'Wonders of Geology') corresponds with the above described *bones of the foot.*"—*Professor Owen.* "Brit. Assoc. Rep." p. 140.

fossa is simple, and somewhat deeper than the anterior. On the whole, the aspect of this humerus more closely corresponds with that of the crocodiles than with its homologue in the ordinary lizards.

Thus, after the lapse of fifteen years, two important elements of the skeleton of the Iguanodon contained in the Maidstone fossil are for the first time determined. The small size of the humerus, as compared with that of the femur, seemed at first to present an insuperable objection, and it occasioned Dr. Melville and others of my scientific friends to hesitate ere they received my interpretation of a bone which had so long proved enigmatical; but the difference is not greater than obtains in many other fossil saurians,[1] as well as in recent Lizards. The length of the Maidstone humerus is about twenty inches; that of the contiguous femur, thirty-three inches; but as the latter is flattened and extended by compression, the difference is probably not more than one-third. The Isle of Wight thigh-bone is three feet long: the largest specimen I have seen is four feet eight inches in length: the average length of the femur in the adult may be estimated at four feet five or six inches: the humerus from the Isle of Wight is, therefore, not relatively longer than that in the Maidstone Iguanodon.

I have lately seen a fine distal extremity of a humerus of the Iguanodon, that was collected from the cliffs at Hastings by S. H. Beckles, Esq., and I have obtained a caudyloid extremity of a humerus one third larger than the specimen of which a cast is placed in *Case C*.

Metacarpals, Phalangeals, and Unguals.—*Wall-case C, right-hand shelf in lowest compartment.*—I have sought in vain for some certain indication of the bones of the fore-arm;

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[1] "C'est un fait à peu près général que les membres antérieurs des reptiles crocodiliens et lacertiens sont plus courts et plus faibles que les postérieurs; chez quelques espèces la différence est très-prononcée. Mais nos reptiles fossiles des environs de Caen annoncent une disproportion beaucoup plus forte encore entre ces membres: le Pœkilopleuron, le Sténéosaurus de Quilly, les Téléosaurus, en fournissent la preuve. Ces derniers surtout avaient les membres antérieurs d'une excessive petitesse; les deux paires de membres différaient entre elles plus peut-être qu'elles ne diffèrent les Gerbilles et les Kangaroos."—Deslongchamps, *Mémoire sur le Pœkilopleuron Bucklandii*, p. 81.

but with the supposed *radius* of the Maidstone Iguanodon, I lost the sole relic that could reasonably be referred to that member of the anterior extremity. The only specimens in the Museum that appear to belong to the fore-arm of the Iguanodon, are the two small subcylindrical bones of a jet black colour, that are affixed to the left hand side of Case *C*, above the middle shelf. These were dug up from a bed of weald clay near Rusper in the west of Sussex, with many bones of a young Iguanodon; I have a beautiful femur, 14 inches long, that was found with them. These fossils are, however, too imperfect to admit of satisfactory interpretation, till some clue is obtained as to their nature from more instructive specimens.

Metacarpals.—I have not seen any bones that could be ascribed to the carpus; but of metacarpals several have been found, which are unquestionably referable to the Iguanodon. The two fine metacarpals in the Maidstone Iguanodon (*Lign.* 65, No. 6) appear to me decisive on this point; an outline of one of these is given in *Lign.* 63, *fig.* 4. These bones lie in close contact, and though somewhat distorted by compression (as are all the bones in that specimen), still their characters are well defined. A transverse section of one of them is shown, *Lign.* 63, *fig.* 4, *a*; in chiselling away the surrounding stone, one of these metacarpals broke transversely, and became detached, and a drawing was made before it was replaced and cemented in its original situation.

When I had ascertained that the supposed radius was the humerus, it occurred to me that the two bones in question might be the *radius* and *ulna;* but upon repairing to the Museum, and examining the specimen anew, I found that my original interpretation was the true one; as the intelligent visitor may convince himself by a careful inspection, for the extremities of both bones are exactly alike. The proximal ends, which are distinctly visible on the side of the block of stone in which they are imbedded, are in close contact, and both present the same form; there is not the slightest difference between them; they closely resemble those of the metatarsals: that is, they are compressed laterally, are higher than wide, and have a nearly flat articular surface. The shafts are subcylindrical, long, and slender, and the distal ends form two well-marked trochlear articulations. If they

were the bones of the fore-arm (as Professor Owen presumes them to be[1]), the *ulna* would be characterised by its *olecranon* or large proximal end, and the *radius* by its carpal extremity; but the proximal as well as the distal ends of the two bones are in every respect similar to each other, and present the usual characters of metacarpals.

A slender phalangeal bone, imbedded in another part of the Maidstone specimen (*Lign.* 63, *fig.* 5), is probably one of the second series of the fore-foot.

In Wall-case *C*, there is a group of four metacarpals, or metatarsals, of a saurian, which differ from the known corresponding bones of the Iguanodon, and may probably belong to another species or perhaps genus. These bones are respectively 8 inches, $7\frac{1}{2}$ inches, $6\frac{1}{2}$ inches, and $3\frac{1}{2}$ inches in length.

Ungual Bones of the Fore-foot?—Wall-case C, lowest compartment.—In *Lign.* 63, *fig.* 7, is a reduced outline of a compressed, hook-shaped, ungual bone, with curved lateral grooves, which closely resembles the claw-bone of the Iguana; it is figured and described in my "Geology of the S. E. of England" (Pl. III. fig. 1), as probably the nail-bone of the fore-foot of the Iguanodon, but of course upon no other grounds than its presumed analogy; this specimen was seen by Baron Cuvier, who concurred in the probability of the conjecture.

There are two specimens of this kind in the Case before us. The largest has the distal extremity destroyed: if perfect, it would be four inches in length; the vertical diameter of the articular end is $2\frac{1}{2}$ inches, and the transverse but little exceeds an inch; proportions altogether different from those of the unguals of the hind foot. Whether, as the relatively slight humerus, and the elongated metacarpal bones and phalangeals seem to indicate, the fore limbs of the Iguanodon were long and slender, and the toes armed with curved claws as in the Iguana—an inference which appears to

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[1] *Palæontographical Monograph*, 1851.—"The radius and ulna lie with their proximal ends next the right hand upper corner of the slab of the Maidstone specimen, the latter being distinguished by its prominent olecranon, which is rounded as in the great Monitor (*Varanus Niloticus*)."—p. 112.

me highly probable—is a question that cannot be determined until the bones of the anterior extremity are found, either in juxtaposition, or collocated in such manner as to demonstrate their natural relations and connexions.

HINDER EXTREMITIES OF THE IGUANODON.—*Wall-case C.*—Several specimens of the femur or thigh-bone, and of the tibia and fibula or leg-bones, and of the metatarsal, phalangeal, and ungual bones of the hind feet, have from time to time been obtained from various localities. The first indication of the colossal magnitude of the reptiles whose teeth and bones were imbedded in the Wealden deposits, was the fragment of a thigh-bone, consisting of a portion of the middle of the shaft, which is of a quadrangular form; and this was so stupendous, shapeless, and unintelligible, that many years elapsed before I could ascertain to what part of the skeleton it belonged. This first discovered specimen is figured in "Fossils of Tilgate Forest," Pl. XVIII.

It not unfrequently happens that a fragment of a thigh-bone may be obtained from a quarry, and after an interval of some weeks, the corresponding portions be exhumed. This was remarkably exemplified in the first specimen which revealed to me the peculiar characters of the femur of the Iguanodon. The distal, or condyloid extremity of a gigantic femur, firmly impacted in a block of Tilgate-grit, was found in the quarry at Cuckfield: as the fracture was evidently recent, I requested the quarry-men to make diligent search for the corresponding portion, but without success. Several months afterwards, upon a fresh explosion of the rock, the head of a large bone was found loose among the fallen mass; but there were no indications that it belonged to the specimen previously found, and it was regarded as another relic of some one of the colossal animals whose bones are distributed in the Wealden deposits. Teeth, fragments of bones, and other fossils, were from time to time obtained from the same quarry, and at length a huge quadrangular mass of bone, similar to the portion that had so long been in my possession, and had defied all attempts to ascertain its character. It was some time before it occurred to me, that these three pieces of colossal bone might belong to the same specimen; but eventually they were found to correspond, and upon cementing them together, the femur

LIGN. 61.

LEFT FEMUR OF THE IGUANODON; ANTERIOR ASPECT.

($\frac{1}{10}$ *nat. size.*)

a. Outer trochanter.
b. Median trochanter.
c. Inner condyle.
d. Outer condyle
e. Anterior intra-condyloid fissure.
f. The head of the femur.

of the Iguanodon was, for the first time, developed.

In the Case before us, there are several splendid specimens of this gigantic member of the skeleton of the Iguanodon—some of prodigious magnitude; others that must have belonged to reptiles but recently hatched, or else to a very diminutive species of the same genus: the former is the most probable conclusion.

FEMUR OF THE IGUANODON.—*Wall-case C* (*ante*, p. 227).—The femur of the Iguanodon is remarkable from the combination of mammalian characters which it presents in its well-marked head and neck, trochanters, condyles, and medullary cavity. The head (*Lign.* 61, *f.*) is hemispherical, and projects inwards over the shaft, as in the mammalia; there is no appearance of a ligamentum teres. A flattened lateral process or trochanter (*a*) forms an external buttress or boundary to the neck of the bone, from which it is separated by a deep, narrow, vertical fissure.

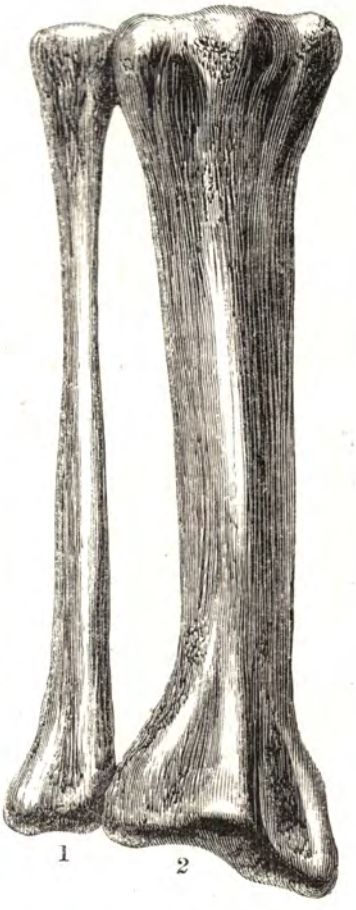
The shaft of the bone is subquadrangular; a slightly elevated ridge, produced by the union of two broad, flat, longitudinal surfaces, indicating the attachment of powerful muscles, extends down the middle of the anterior face, and diverging towards the inner condyle, gradually disappears. The shaft terminates below, in two large, rounded, laterally-com-

pressed condyles (*c*, *d*), which are separated in front and behind by a deep furrow (*e*).

Near the middle of the shaft, the mesial or inner edge forms a compressed ridge, which extends into an angular median projection or trochanter (*b*).

Thus the upper part of the femur may be recognised by the presence of the outer trochanter (*a*); and if that be absent, by the fractured surface indicating the position it occupied. If a fragment of the middle part of the shaft only is found, the flattened angular spaces, and the sub-median trochanter (*b*), or the mark of its attachment, will identify it. The lower end may be known by the deep grooves between the condyles both in front and behind.

The medullary cavity is very large, and generally filled with sandstone: it is sometimes occupied by white calcareous spar, spangled with golden pyrites.



LIGN. 62.
1. FIBULA; 2, TIBIA, OF THE IGUANODON.
($\frac{1}{10}$ *nat. size.*)

TIBIA AND FIBULA.—*Wall-case C.* (*ante*, p. 227).—The bones of the leg, though presenting deviations from those of the Iguana, manifest a close affinity to the lacertian type.

The head of the *tibia*, is subtriangular, and slightly excavated to receive the condyloid extremity of the femur. The shaft is subcylindrical, and very strong, with a large medullary cavity; its distal end is transversely oblong and very thick, and terminates on the inner aspect in a strong buttress.

The *fibula* is a long slender bone, with a subcylindrical shaft, widest in its antero-posterior diameter; it is flattened on the tibial aspect, and terminates above in a laterally compressed head, which is in close apposition to the tibia; its

distal extremity is thick and broad. This bone almost equals the tibia in length ; the figure, *Lign.* 62, 1. is somewhat too short in proportion to the corresponding tibia.

Bones of the thigh and leg of Iguanodon, in Wall-case C (*ante*, p. 227).—The fragment of an enormous thigh-bone on the uppermost shelf; this is the first specimen discovered, and is figured in my "Fossils of Tilgate Forest," Pl. XVIII.

Femur, tibia, fibula, and two metatarsals of a young Iguanodon. These were found near each other, imbedded in a block of sandstone, and evidently belonged to the same individual. This is a most valuable series, because it affords data for determining the relative length and size of the thigh, leg, and foot.

A fine shaft of a femur ; marked No. 4.

Part of the femur, the tibia and fibula of the same individual. These massive bones were exhumed from a bed of clay, and were lying close to each other ; they are evidently the bones of the same individual ; the femur is labelled No. 2 ; it is on the right extremity of the shelf ; the tibia and fibula are on the extreme left ; but by the aid of the table (*ante*, p. 227), they may be readily identified.

Femur, marked No. 3. This is a remarkably fine and nearly perfect femur.

The largest and most perfect femur of the Iguanodon in the Museum (labelled No 1). It was dug up from the Weald clay at Loxwood, to the west of Horsham, and with the exception of the shaft, was broken into numerous pieces in extracting it. The shaft is figured in Sir Roderick Murchison's Memoir on Western Sussex ; the first contribution of that distinguished geologist to the science he has so greatly advanced by his genius and indomitable perseverance and activity. It was many years in the state in which it is there represented ; but at length my warm and generous friend, the late Earl of Egremont, obtained it for me, together with all the fragments, and many other bones that were exhumed at the same time by J. King, Esq. ; and I succeeded in repairing the bone as it now appears. The form of the head, condyles, and the two characteristic trochanters, are well displayed.

Femur, marked No. 5.—This is a fine specimen, though the condyloid end is crushed. It was from the ferruginous sandstone of Cuckfield.

It is the thigh bones, marked Nos. 4 and 5, which Professor Owen observes "we might conclude to be *humeri*."—("Brit. Rep." p. 137.) And in the next page he describes a bone (an undoubted *femur*) that corresponds "in form with the bones Nos. 4 and 5 of the Mantellian Collection." Professor Owen then observes—"As the *absence* of the *deep fissure* between the condyles of the femur is repeated in the humerus of the Iguana, so may its *presence* be repeated in the *humerus of the Iguanodon*," p. 138. The remarks of a correspondent, Mr. Holmes, are then inserted to "support the view I had taken of their nature." (*See note to p.* 286.)

On the narrow front shelf (*ante*, p. 227,) there is a femur of a very young Iguanodon, but nine inches in length.

Bones of the hind Feet; *metatarsals, phalangeals,* and *unguals.* The bones composing the hind foot of the Iguanodon, have already been alluded to, as presenting in their massive proportions the characters of mammalian rather than of reptilian metatarsals. No specimens have come under my notice that could with certainty be assigned to the tarsus. I have some very massive and solid bones of a cuboidal form, but much waterworn, that were collected from the shore at Sandown Bay, whence the gigantic phalangeal, figured by Dr. Buckland in "Geol. Trans.," was obtained; and these specimens may possibly belong to the tarsus of the Iguanodon.

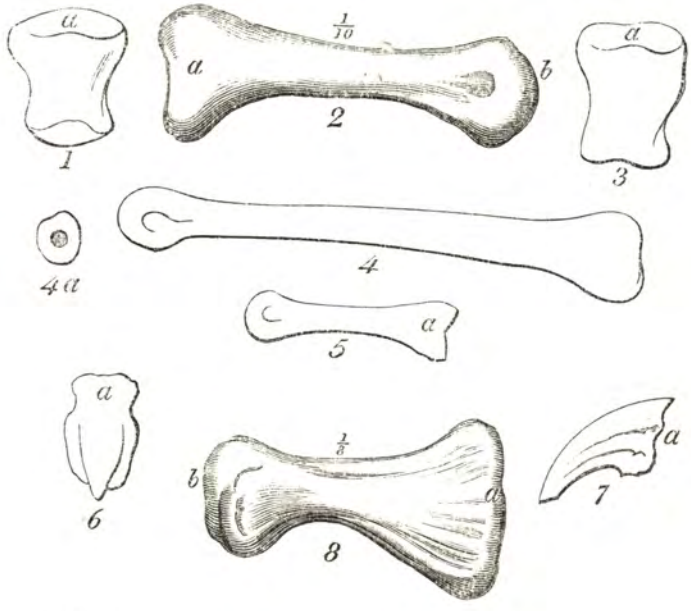
Metatarsals.—Wall-case C, lower shelf.—A considerable number of metatarsals belonging to animals of various ages and magnitude have been collected; and there are some fine specimens in the Case before us. They are easily recognised by their peculiar form, as shown in *Lign.* 63, fig. 8.

The proximal extremity is very much compressed laterally, the vertical diameter being thrice that of the transverse; the articular surface is almost flat. The bone is contracted in the middle, and forms at the distal end a bold trochlear articulation divided by a vertical depression.

The large metatarsal on this shelf is figured in "Fossils of Tilgate Forest," Pl. XV. fig. 8; it has the following proportions:—

Length	10 inches.
Proximal end; vertical diameter . . .	7
——— transverse diameter . .	$2\frac{1}{2}$
Distal end; vertical diameter	$4\frac{1}{4}$
——— transverse diameter . . .	$3\frac{1}{4}$

The proximal articular surface is nearly flat; the distal end that unites with the first phalangeal is a bold trochlear articulation.



LIGN. 63.—BONES OF THE FEET OF THE IGUANODON, AND MEGALOSAURUS.

(*Wealden. Tilgate Forest.*)

Fig. 1. Metatarsal of Iguanodon: upper surface; original six inches long.
2. Metacarpal bone of Megalosaurus.
3. Under surface of fig. 1.
4. A metacarpal bone of the Maidstone Iguanodon; the original 14 in. long.
4*a*. A transverse section of the same, showing the medullary cavity.
5. One of the first or second phalangeal bones of the fore-foot.
6. View from above of a claw-bone of one of the hind-toes; $\frac{1}{6}$ *nat. size.*
7. Profile of claw-bone of fore-foot: $\frac{1}{6}$ *nat. size.*
8. Metatarsal, $\frac{1}{8}$ *nat. size.*
a. Denotes the *proximal* articulation.
b. The *distal* extremity.

Phalangeals.—The first phalangeals that articulate with the metatarsals are less arched, and the extremities are more equal, than in the preceding bones.

The second and third phalangeals are more subcylindrical; the ungual phalanx exceeds the length of the latter, in the only connected series I have met with.

In the Maidstone specimen there are several metatarsals, phalangeals, and unguals of the hind-feet, of which I shall treat more particularly. But I would here direct attention

to two phalangeals in this Case (the one is a cast of a bone in the Maidstone fossil), which are remarkably abbreviated; these are probably median phalanges, but their position in the series is not shown in any specimen that has come under my notice.

Unguals, or distal phalangeals.—Wall-case C, Lowermost compartment.—The ungual bones, or those which constituted the nail or claw, and were covered by a horny integument, are very large, depressed, and broad above, with two deep curved lateral grooves with rounded margins, which are often impressed with vascular furrows. The proximal end has a transverse, irregularly elliptical, shallow depression, for articulation with the penultimate phalangeal. *Lign.* 63, fig. 6, is the outline of an ungual bone of the hind foot from the Maidstone specimen, and shows the broad margins separated from the median convexity by the deep vascular lateral furrows.

There is considerable variation in the convexity of the ungual bones, and in its direction; in some instances, it is nearly straight, and the lateral lobes are symmetrical; other examples are twisted obliquely outwards, and the furrows are partially obliterated. These differences, doubtless, have relation to the respective toes to which these phalanges belonged. The straight unguals are probably those of the middle toes; those with the oblique outward curve may have belonged to the outer or inner toes. The largest specimens of the ungual bones I have seen are five inches in length, three in breadth, and two in height at the proximal end.

The following are the respective lengths of a consecutive series of phalangeals in the collection of S. H. Beckles, Esq.:—

Metatarsal	8 inches.
Proximal phalangeal	4½
Second phalangeal	3½
Ungual, or distal phalangeal .	5

On the shelf in the lowest compartment of this Case, there is a fine ungual bone, 4½ inches in length, from Tilgate Forest, (No. 384,) with the characteristic lateral furrows; this specimen was imbedded in a block of the most compact Tilgate grit, and was extracted with great difficulty: hence the roughness of the surface occasioned by the chisel in clearing the bone from its matrix.

HORN OR DERMAL TUBERCLE OF THE IGUANODON.—*Wall-case C, (on the narrow front ledge, ante,* p. 227.)—Allusion has been made in an early page of this chapter to a fossil obtained from the quarry at Cuckfield, soon after my discovery of the teeth of the Iguanodon, which some of my scientific friends supposed to be the lesser horn of a Rhinoceros. This very curious relic was figured and described in 1827, in my "Fossils of Tilgate Forest" (Pl. III. fig. 5), as the frontal tubercle or *Horn of the Iguanodon;* Mr. Pentland, the eminent naturalist, having first suggested its true nature.

In the "Geology of the S. E. of England," (published in 1833,) this specimen was again figured and described, its dermal character having been confirmed by Baron Cuvier, to whom I showed it on his visit to London.[1] This interesting fossil is placed on the front ledge of Case *C*. Two or three dermal bones of this kind have since been found; and I have a series of three conical tubercles of a similar character implanted in a coarse osseous substance, which closely resemble, on a gigantic scale, the dermal spines on the back of the well-known Australian lizard, termed the "*Moloch.*"

This fossil is of a conical form, slightly bent, with an obtuse apex. It is 4 inches high; and the base, which is of an irregular elliptical form, and slightly excavated, like the corresponding part of the dermal spine of the Hylæosaurus, is 3.2 inches in the largest diameter, and 2.1 inches in the shortest. (*Lign.* 67, *fig.* 2.) Its structure presents that peculiar disposition of the osseous fibres which is observable in the dermal bones of certain reptiles; the surface is dis-

[1] "Among the recent genera of lizards the Iguanas are distinguished by their exuberant dermal appendages; many of the species have enormous serrated processes on the back; others on the tail and guttural pouch, while some have warts or horny protuberances on the head. These, however, are so small,—the horn in the most favoured species, *Iguana cornuta,* being scarcely a quarter of an inch high in an animal five feet long,—that no one could have imagined the corresponding part of an extinct reptile would have been preserved in a fossil state. This relic is of so extraordinary a nature, that although it has been noticed in my former work, I am anxious to dwell on it in this place, that I may introduce the remarks of M. Cuvier, by whom it was examined during his last visit to London, and at whose suggestion a more accurate representation is here given, than that in the 'Fossils of Tilgate Forest.'"—"Geology of the S. E. of England," p. 312. 1 vol. 8vo, 1833.

tinctly impressed by the vessels of the integument by which it was originally covered.

There is no evidence to prove that this bone belonged to the Iguanodon, but that it is a dermal tubercle there cannot be any reasonable doubt; and as it closely resembles the frontal horn of the *Iguana cornuta*, it is highly probable it was such an appendage: or it may have been one of a series extending down the back. In the present state of our knowledge, we are warranted in retaining the name sanctioned by the illustrious Cuvier.[1]

Dimensions of the Hinder Limbs of the Iguanodon.—Although the prodigious size of the hind limbs of the herbivorous reptile of the Wealden is sufficiently apparent from the single bones deposited in the British Museum, and described in the preceding pages, yet with the view of conveying to the reader a just idea of the stupendous proportions of this part of the skeleton of the Iguanodon, I will offer a few remarks on some enormous bones, which have been collected from the Wealden deposits of Tilgate Forest and the Isle of Wight, in the course of the last few years, and which are either in my own possession, or in the collections of my friends.

"In the course of last autumn I procured from the cliffs near Brook Point,—a locality well known to the British geologist from the fossil forest exposed at its base,[2]—portions of two corresponding femora, tibiæ, and several vertebræ, fragments of ribs, &c. of Iguanodons. The most entire bone is the left femur; it consists of the shaft from above the popliteal space to the root of the outer trochanter: the head and condyles are both wanting; the inner trochanter remains: the length of this fossil is 3 feet; circumference of the shaft

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[1] After the lapse of eighteen years, the Hunterian Professor, it would seem, has discovered that this "horn" is an *ungual bone:* for, alluding to a bone of the Mosasaurus, Professor Owen remarks:—"The *phalanx* in question much resembles that in the British Museum (No. 384 Mantellian Collect.), which has been described as the '*Horn of the Iguanodon.*'"—("Fossil Reptilia of the Cretaceous Formations," 1851, p. 36.) I have again carefully examined three of these bones, and may remark, that in addition to the reasons assigned in the text, the absence of lateral furrows in the dermal horns or spines, and the constant presence of such vascular grooves in every reptilian ungual phalanx hitherto found in the Wealden, and the form of the base, substantiate my opinion.

[2] "See my 'Geological Excursions round the Isle of Wight,' p. 277."

27 inches. The greatest thickness of the wall of the shaft is 2 inches; the diameter of the medullary cavity 5 inches by 3. In all the femora which I have examined, the medullary canal extends from above the condyles to within one-third of the top of the bone.[1] Of the right femur, which from its correspondence in size is probably referable to the same individual as the left, two large portions of the shaft were alone obtained. Now, if we take as a scale of proportions the large femur in the *Wall-case C*, the bone above described, if perfect, would be of the following dimensions:—

Total length	4 feet	8 inches.
Circumference of the head exclusive of the outer trochanter	3	2
——————— the shaft at the base of the middle trochanter	2	1
———————the distal end round the condyles	3	6

"A tibia found with the above, consists of about two-thirds of the shaft, with the distal or tarsal extremity nearly entire; it measures as follows:—

"Length along the middle of the shaft	27 inches.
Length to the distal inner process	32
Circumference of the distal or tarsal end	25
——————————— middle of the shaft	18
——————————— upper part	$20\frac{1}{2}$

Probable length of this tibia when perfect, 4 feet.

"A fragment of the shaft of another tibia is 23 inches in circumference; and the distal end of one from Sandown Bay 27 inches.

"As a contrast to these gigantic remains, bones of the extremity occasionally occur so small, yet so compact, as to suggest the probability that they may belong to distinct species; but at present I have not been able to detect other characters which would warrant such an inference. A left femur in my possession, from Rusper in Sussex, is $14\frac{1}{2}$ inches

[1] "In this enormous bone the internal structure is beautifully preserved; sections properly prepared exhibit the peculiar form and proportions which Mr. Bowerbank considers to be characteristic of the reptilian type. That eminent microscopic observer has kindly favoured me with his measurements of the bone-cells in portions of this femur. The general average of the proportions of the length and diameter of the cells is as one to eleven; the length being $\frac{1}{600}$ and the diameter $\frac{1}{6600}$th of an inch."

long; the circumference of the shaft 6 inches: this, therefore, is but one-fourth the size of the specimen from Brook. The lower portion of another thigh-bone, which in the characters of its condyloid extremity entirely agrees with all the recognised femora of the Iguanodon, is but $3\frac{1}{4}$ inches in circumference round the condyles, and but $2\frac{1}{4}$ round the shaft immediately above them; the total length of this femur, when entire, could not have exceeded $4\frac{1}{2}$ inches.

"In general the circumference of the shaft of the thigh-bone immediately below the base of the inner trochanter, is nearly equal to half the length of the entire bone; for example, the large right femur from Loxwood, (No. 1,) which is 3 feet 8 inches long, is 21 inches round the shaft. But there are exceptions to these proportions; thus, a femur from Brook Point, presented by me to the Hunterian Museum of the Royal College of Surgeons, is relatively shorter, for it is only $3\frac{1}{2}$ feet long, while the circumference of the shaft is 24 inches. The thigh-bone of the Maidstone fossil is of more slender proportions.

"The tibia is about one-tenth shorter than the corresponding femur; and the fibula somewhat shorter than the tibia.

"With the view of affording a general idea of the dimensions of the known parts of the skeleton of the Iguanodon to which the largest femur in my possession belonged, the following list, calculated from the average size of numerous specimens, is subjoined. The length of the corresponding bones in the Maidstone fossil is added for comparison:—

	Iguanodon from the Isle of Wight.	Maidstone Iguanodon.
"Femur, length of	4 feet 8 inches.	2 feet 9 inches.
Tibia	4 1	2 6
Fibula	3 8	
Humerus	3 2	1 8
Clavicle	3 8	2 4
Scapula	3 4	2 1
Metacarpals	2 0	1 2
Ilium	3 10	2 6
Metatarsals	2 0	1 2
Ungual bones	$5\frac{3}{4}$	$3\frac{1}{2}$ "[1]

THE MAIDSTONE IGUANODON.—*Case* 23.—(See *Plan of Room* III. *ante*, p. 139.)—The fine old town of Maidstone, in Kent,

[1] From a "Memoir on the Osteology of the Ignanodon and Hylæosaurus;" published in the "Philos. Trans." for 1849, pp. 282, 283.

is situated on the gentle slope of a valley of *Greensand*, through which the river Medway winds its way to "The Nore," and flows into the British Channel. The country around is deeply covered by diluvial clay and loam, in which teeth and bones of species of Elephant, Horse, Ox, and other pachyderms, are occasionally found. These beds are of considerable thickness, amounting in some localities to forty feet.

The grey arenaceous limestone of the cretaceous formation, provincially termed *Kentish-Rag*, occurs interstratified with the more friable beds of greensand, and has long been extensively quarried in the immediate neighbourhood of Maidstone ; the most calcareous varieties being used for lime, and the harder rock for buildings and roads.

On the north-west of the town, the greensand strata dip beneath the upper series of the Cretaceous formation, viz. the *Galt*, *Chalk-Marl*, and *Lower-Chalk*, that appear in succession on the surface, in passing to the neighbouring North Downs, which are a continuation of the Surrey range of *Upper or flinty Chalk*, and extend eastward, till they terminate in the precipitous cliffs of Dover.[1]

The greensand strata in this locality abound in the marine shells which characterise the lowest subdivision of the Chalk formation, viz. the Atherfield or Neocomian series, to which the elaborate researches of Dr. Fitton have imparted a high degree of geological interest.

Trigoniæ, pernæ, gervilliæ, terebratulæ, ammonites, nautili, remains of crustaceans, scales and teeth of various kinds of fishes, bones and teeth of marine saurians (*Polyptychodon*, *ante*, p. 200), remains of turtles, &c., occur in these beds in the vicinity of Maidstone. Waterworn blocks of fossil wood perforated by boring-shells, fragments of stems, and branches of monocotyledonous and coniferous vegetables, are also occasionally found imbedded with the marine exuviæ, having evidently been transported by rivers or land-floods, and drifted into the bed of the chalk-ocean.

At Rock Hill, on the south-western side of the river, at about half a mile from Maidstone, there is an extensive quarry of Kentish-Rag in the possession of Mr. W. H. Bensted, which, thanks to the sagacity and zeal of its intelligent proprietor,

[1] See "Wonders of Geology," p. 297.

has acquired an enduring celebrity in British Palæontology; for from this quarry was obtained, a few years since, the most considerable portion of the skeleton of the Iguanodon hitherto discovered.

Mr. Bensted, whose active and intelligent mind was alive to the various objects of interest with which he was surrounded, and who had assiduously collected the fossils that were from time to time brought to light in his quarry, had instructed his workmen to preserve every shell or bone imbedded in the rock.

In May 1834, upon blasting a large block of limestone, the workmen observed in some of the masses that were blown off, pieces of a brown substance, which they supposed to be petrified wood; they preserved some of the largest portions for the inspection of Mr. Bensted, who at once perceived they were fragments of the bones of some gigantic animal. He therefore directed that every piece should be collected, and succeeded in regaining some fragments that had been taken to the river-side; and after much trouble he gathered together the dissevered masses of rock, which, when united, formed the specimen in *Case* 23.

Mr. Bensted assiduously cleared away the investing limestone, as far as the very brittle condition of the bones would admit; and when I visited him, in company with W. D. Saull, Esq., the characters of the principal bones were sufficiently exposed to view, to admit of my recognising them as analogous to those which I had ascribed to the Iguanodon.

Some gentlemen of Brighton, anxious that a specimen which shed so much light on the osteology of the Iguanodon, should be placed in the hands of the individual who first discovered the teeth and bones of that extraordinary type of reptilian organization, purchased the fossil of Mr. Bensted, and presented it to the author.[1] It was brought to me by

[1] The following is a list of the donors; the proposal originated with the two gentlemen whose names are placed first.

M. Ricardo, Esq.	Sir Richard Hunter.
Horace Smith, Esq.	E. Lindo, Esq.
Rev. J. S. M. Anderson.	J. Masquerier, Esq.
Thomas Attree, Esq.	Dr. Price.
George Basevi, Esq.	Rev. Thomas Rooper.
Thomas Bodley, Esq.	W. Tennant, Esq.
Dr. Hall.	Rev. H. M. Wagner.
R. Heaviside, Esq.	J. Sarel, Esq.

Mr. Bensted in the fragmentary and shapeless state in which it was collected, with a drawing and plan of the respective bones and pieces of stone, to assist me in its reparation. How far the labour spent in its restoration was successful, is shown by the present state of this interesting group of bones of the same individual.

"The genuine worker and searcher after truth may well conceive my feelings" upon receiving so gratifying a tribute of respect from my fellow-townsmen, and so unexpected a confirmation of the correctness of my interpretation of the scattered bones of a reptile whose osteology presented such anomalous characters; for to my great delight, I found that every bone I had ascribed to the Iguanodon solely from analogy, was present in the Maidstone specimen.

LIGN. 64.—IGUANODON QUARRY, OF MR. W. H. BENSTED, NEAR MAIDSTONE.

The section exposed in the quarry whence this fossil was obtained, is shown in the annexed sketch from a drawing with which Mr. Bensted favoured me, when he delivered the specimen into my hands.

The Kentish-rag is seen in nearly horizontal layers, separated by thin seams of loose sand. A deep vertical chasm intersects the strata, and this fissure was filled with loam, gravel, and other alluvial detritus, which constitute the

immediate subsoil of the district, and form a bed of from ten to twenty feet thick above the regular strata of the quarry. This chasm had evidently been a watercourse before the deposition of the drift, for the face of the rock on each side bore unequivocal marks of the long-continued action of currents.

The mass of limestone in which the Iguanodon was imbedded, was situated on the left of the fissure, and near the upper part of the section.[1]

The intelligent reader will remark that the geological position of the Maidstone Iguanodon, forms a striking exception to the circumstances under which all the remains of this terrestrial reptile hitherto described were obtained; for while in the Wealden deposits the bones were associated with fluviatile and terrestrial exuviæ only, this specimen was imbedded in a marine stratum, and marine shells were attached to the femur. This fact, however, in no wise affects the validity of the arguments previously advanced as to the fluviatile origin of the Wealden Formation. It merely shows that part of the delta of the ancient river had subsided, and was covered by the ocean that deposited the greensand strata, whilst the Country of the Iguanodon still remained above the waters; so that the carcass of one of these reptiles was drifted out to sea, and became ingulfed in the deposits then in progress; in like manner as at the present day, remains of land quadrupeds may not only be imbedded in the deltas of rivers, but also in the depths of the ocean.

There are two bones missing in the specimen, and which, I fear, are irretrievably lost. One is the ungual bone represented at fig. 5. It was narrower, and more convex and elongated, than the ungual that remains near the metatarsal fig. 4. This bone was $3\frac{1}{2}$ inches long: its proximal end was $1\frac{1}{2}$ inch in transverse diameter, and $1\frac{1}{4}$ in the vertical; the distal end was $\frac{3}{4}$ inch wide.

The other missing bone was a remarkably abbreviated phalangeal, imbedded near the former. Its dimensions were as follow:—

Antero-

[1] See "Medals of Creation," p. 431, for an account of the molluskite, discovered in the Maidstone Iguanodon quarry, by Mr. Bensted.

LIGN. 65.—REMAINS OF THE SKELETON OF A YOUNG IGUANODON, IMBEDDED IN A BLOCK OF KENTISH RAG: FROM NEAR MAIDSTONE.
(*Size of the original, 6 ft. 4 in. by 6 ft. 2 in.*)

This specimen consists of a considerable portion of the skeleton of a young animal, the bones being disconnected, distorted, and imbedded in the rock in a very confused manner. The following are those I have been able to determine:—

Figs. 1, 2. Right and left femur: 33 inches long.
3. Tibia: 20 inches long.
4, 4, 4. Metatarsal and phalangeal bones.
5, 5. Ungual bones.
6. Two metacarpal bones: 14 inches long. Near these are portions of small cylindrical bones, apparently fragments of abdominal costal processes.
7. Humerus: 20 inches long.
8* 8* Dorsal vertebræ. The group on the right belongs to the same series as that on the left: the * * point out their junction. In my "Wonders of Geology," the true form of the specimen is represented.
9. Fragments of Ribs.
10, 10. Clavicles: 28 inches long. Under the distal end of the lowermost clavicle there is a bone not yet made out.
11, 11. Iliac bones.
12. Chevron-bone, or hæmapophysis. Beneath this process there is a hatchet-shaped bone, which I have not been able to decypher.
13. A tooth and the imprint of another. Unfortunately lost in removing the specimen from Brighton.
14, 14. The two corresponding portions of a Scapula.
15. The distal part of the other Scapula.
16, 16. Caudal vertebræ.
* Indicates the cavity left by the bore in which the charge was placed to blast the stone.

Antero-posterior diameter	1 inch.
Transverse	$2\frac{1}{4}$
Vertical	$1\frac{3}{4}$

The impressions left by these two bones remain distinct on the stone, and as, fortunately, I had moulds taken of them when in my possession, casts of these important parts of the skeleton may be restored.[1]

As the bones in the Maidstone Iguanodon have been described when treating of the anatomical characters of the several parts of the skeleton, it is unnecessary to extend this notice of a specimen whose interest chiefly depends on the collocation of the principal elements of the osteology of the colossal reptile of the Wealden.

PHYSIOLOGICAL INFERENCES AS TO THE STRUCTURE AND ECONOMY OF THE IGUANODON.—In instituting a comparison between the maxillary organs of the Iguanodon, and those of the existing herbivorous lizards, with the view of obtaining

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[1] The *Lignograph* 65, is merely a diagram or plan to show the position of the several parts, without any pretensions to accuracy, and intended to assist the visitor in identifying the bones referred to in the previous descriptions. The original drawing, from which the lithograph published in the "Monograph of the Palæontological Society" was taken, was executed by Mr. Dinkel, with great care, when the specimen was in my museum at Brighton (see Appendix G.); I therefore regret that the lithograph is a modified copy, and does not convey an accurate idea of the original. The lithograph in my "Wonders of Geology," sixth edition, Pl. III., is very faithful, but on too small a scale to admit of anatomical details.

The palæontologist desirous of ascertaining the structure of the Iguanodon, and the relative proportions of the respective bones, will I fear be embarrassed by the manifest difference between the measurements of some of the bones given by me, and those by Professor Owen in the "Monograph" referred to. The scale of Professor Owen's Plate XXXIII. is mentioned to be "2 inches to the foot" = $\frac{1}{6}$; and the bone which is termed the *ulna*, (but which I believe to be a metacarpal bone,) is stated to be *eighteen inches long*, (See "Monograph," p. 114); yet in the Plate XXXIII. this bone measures $2\frac{1}{3}$ inches, which is only equal to between 13 and 14 inches; a length which nearly agrees with that given by me, namely, 14 inches.

The "genuine worker" is therefore requested to judge for himself, by a careful examination of the specimen; for there are several other incongruities equally important; for example, the Clavicle, which when the specimen was in my possession measured 28 inches, is, according to Professor Owen's table, nine inches longer, namely 37 inches. ("Monograph," p. 113.)

some physiological deductions from their peculiar osteological characters, we are at once struck with their remarkable deviation from all known types in the class Reptilia. In the *Amblyrhynchi*, the most exclusively vegetable feeders of the saurian order, the alveolar process, beset with teeth, is continued round the front of the mouth; the junction of the two rami of the lower jaw at the symphysis presenting no edentulous interval whatever, and the lips not being more produced than in other reptiles; for these creatures chip off and bruise their food, and cannot grind or masticate it: in the Iguanas, as previously shown, the same character exists. In the carnivorous saurians the teeth are also continued to the symphysial suture on each side. The extinct colossal lizards offer no exception to this rule; in the acrodont Mosasaurus of the Chalk, and in the thecodont Megalosaurus of the Oolite and Wealden, the jaws are armed with teeth round the anterior extremity. In short, the edentulous, expanded, scoop-shaped, procumbent, symphysis of the lower jaw of the Iguanodon, has no parallel among either existing or fossil reptiles, and we seek in vain for maxillary organs at all analogous, except among the herbivorous mammalia. The nearest approach is to be found in certain *Edentata*,—as for example in the *Cholœpus didactylus*, or Two-toed Sloth,—in which the anterior part of the lower jaw is edentulous and much prolonged. The correspondence is still closer in the gigantic extinct *Mylodon*, in which the symphysis resembles the blade of a spade used by turf-diggers, and has no traces of incisive sockets; and were not this part of the jaw elevated vertically in front, and the two rami confluent, it would present the very counterpart of that of the Iguanodon.[1]

The great size and number of the vascular foramina distributed along the outer side of the dentary bone, and beneath the border of the symphysis, in the Iguanodon, and the magnitude of the anterior outlets which gave exit to the vessels

[1] In the *Mylodon Darwinii* the rami of the lower jaw anterior to the teeth are contracted vertically, and converge to a longer and narrower symphysis, which is inclined forwards at a more open angle with the horizontal ramus, than in the *Mylodon robustus*, and therefore still more nearly approaches that of the Iguanodon. See Professor Owen on the Mylodon.

and nerves that supplied the front of the mouth, indicate the great development of the integuments and soft parts, with which the lower jaw was invested.

The sharp ridge bordering the deep groove of the symphysis, in which there are also several foramina, evidently gave attachment to the muscles and integuments of the under lip; while two deep pits for the insertion of the protractor muscles of the tongue, manifest the mobility and power of that organ. There are therefore strong reasons for supposing that the lip was flexible, and, in conjunction with the long fleshy prehensile tongue, constituted the instruments for seizing and cropping the leaves and branches, which, from the construction of the molars, we may infer constituted the chief food of the Iguanodon. The mechanism of the maxillary organs, as elucidated by recent discoveries, is thus in perfect harmony with the remarkable characters which rendered the first known teeth so enigmatical; and in the Wealden herbivorous reptile we have a solution of the problem, how the integrity of the type of organization peculiar to the class of cold-blooded vertebrata was maintained, and yet adapted, by simple modifications, to fulfil the conditions required by the economy of a gigantic terrestrial reptile, destined to obtain support exclusively from vegetable substances; in like manner as the extinct colossal herbivorous Edentata which flourished in South America, ages after the Country of the Iguanodon and its inhabitants had been swept from the face of the earth.

Thus in the unlimited production of successional teeth at every period of the animal's existence, in the mode of implantation of the teeth, and in the composite structure of the lower jaw,—each ramus consisting of six distinct elements,—the saurian type of organization is unequivocally manifest; while the intimate structure of the dental organs approaches that of the Sloths, and the subalternate arrangement and reversed position of the upper and lower series of teeth corresponds with that of the Ruminants. And again, the edentulous and prolonged symphysis, and the great development of the lower lip and the integuments of the jaws, as indicated by the size and number of the vascular foramina, present a striking analogy to the Edentata. They who doubt the correctness of this interpretation, should remember that

it is in this order of Mammalia that we find the nearest approach to the Reptilia: in the scaly covering of the skin, the imperfections of the dental system, the smallness of the brain, and the long continuance of the irritability of the muscular fibre after death; which are so many decadencies of organization, so to speak, that indicate a step towards that class, of which the Iguanodon appears to have been the highest type.

If the opinion previously advanced (*ante*, p. 260) be correct, that the anterior part of the spinal column consisted of convexo-concave, and the dorsal of plano-concave vertebræ, the adult Iguanodon must have approached in this part of its skeleton, as well as in its sacrum,—in its massive femora, with their large medullary cavities, trochanters, and condyles,—and in its short and strong metatarsals and phalangeals,—to that of the large herbivorous mammalia.

The position of the hinder limbs (the thighs and legs) in relation to the pelvis, cannot be accurately determined from the data at present obtained; but the form of the head and shaft of the femur, and the character of its articulations and processes, so closely resemble those of the largest pachyderms, as to suggest the idea, that unlike the rest of its class, the Iguanodon had the body supported as in the mammalia, and the abdomen suspended higher from the ground than in any existing saurians.

In fine, we have in the Iguanodon the type of the terrestrial herbivora, which in that remote epoch of the earth's physical history, termed by geologists "*The Age of Reptiles*," occupied the same relative station in the scale of being, and fulfilled the same general purposes in the economy of nature, as the Mastodons, Mammoths, and Mylodons, of the tertiary periods, and the existing Pachyderms.

With regard to the probable magnitude of the individuals to which the largest bones in my collection belonged, a general estimate only can be formed, because the relative proportions of the limbs, head, and body, are still unknown; sooner or later an entire, or a considerable portion of the, skeleton of a young Iguanodon will be brought to light, and yield the information necessary to enable the palæontologist to ascertain the dimensions, and delineate the physiognomy, of the living original.

The size of the largest Iguanodon has been estimated as follows:[1] length of the head, three feet—of the trunk, twelve feet—of the tail, thirteen feet—*total length, twenty-eight feet.*

This statement will surprise the reader who, from the popular notions of the magnitude of the Iguanodon, has entertained the idea that this reptile attained seventy feet in length; but the discrepancy between the above estimate and that first suggested by me, admits of an easy explanation.

In my earliest notices of the Iguanodon, which were published from time to time, as fresh discoveries disclosed new modifications of structure in this prodigious creature, an attempt was made to estimate the probable magnitude of the original, by instituting a comparison between the fossil bones and those of the Iguana; the recent type which the form of the teeth seemed to point out as the one most nearly related to the extinct reptile. It was thus shown that if the proportions were the same in both, the Iguanodon must have attained seventy feet or more in length. But this statement was qualified (more than eleven years since) by the remark—"It is not, of course, pretended that such an estimate can offer more than *a very distant approximation to the truth;* yet it may be confidently affirmed that a reptile, which required a thigh-bone larger than that of the Elephant to support it, could not be of less colossal dimensions. In truth, I believe that its magnitude is here underrated, for, like Frankenstein, I was struck with astonishment at the monster which my investigations had, as it were, called into existence, and was more anxious to reduce its proportions than to exaggerate them. Should subsequent discoveries prove that the Iguanodon more nearly corresponded in the proportions of the tail with the Crocodilian family than with the Lizards, its total length would be much less than is here inferred; and from the shape of some of the metacarpals and phalangeals, it seems highly probable that the original was more bulky in proportion to its length, than the existing Lacertians."

In subsequent notices this opinion was reiterated, and on the discovery of several perfect anterior caudals, I expressed my conviction that the tail of the Iguanodon was shorter than in the Iguana, and instead of being long and round, was

[1] "Brit. Rep." 1841, p. 144.

compressed laterally, and largely developed in a vertical direction. In my Memoir, in the "*Phil. Trans.*" 1841 (pp. 137—140), it is stated that "from the shortness of the caudal vertebræ, and the length of the spinous processes, indicating a great vertical development of the tail, it is probable this organ was not long and slender, as in the Iguana, but approximated more nearly to the tail of the *Dorypphorus*."

"The length of the united head and trunk, according to my estimate,[1] is seventeen feet and a half; by Professor Owen's it is reduced to fifteen feet: a difference of no importance in such merely approximative calculations, particularly when the form of the cranium is unknown. The great discrepancy is in the estimated length of the tail; if the Iguanodon resembled the Iguana in its caudal proportions, its total length would be seventy feet; but if the tail was short, the total length of the animal would, of course, be proportionately reduced, and the most gigantic individuals may not have exceeded thirty feet in length."

A recent discovery, however, supports the idea first suggested by the stupendous size of the bones of the extremities.

In a block of calciferous grit picked up on the sea-shore, I have laid bare a chain of eleven caudal vertebræ, belonging to the middle region of the tail; and the bodies of these bones, instead of being abbreviated, as the shortness of the known anterior caudals led us to infer, are elongated as in the corresponding part of the skeleton of the recent Iguana. The length of four of these vertebræ is equal to that of five dorsals; and their spinous and transverse processes are so well developed, as to show that the tail must have been greatly prolonged—probably, in the same degree as in the existing lizards. The length of the femur of this individual is equal to six caudal, or eight anterior dorsal vertebræ. It is, therefore, according to the present state of our knowledge, not at all improbable, that the largest Iguanodons may have attained a length of from sixty to seventy feet.

Although some important points in the osteology of the Iguanodon are still unknown, we may safely conclude that this stupendous reptile equalled in bulk the large herbivo-

[1] "Geology of the South-East of England," p. 316.

rous mammalia, and was as massive in its proportions; for, living exclusively on vegetables, it must have had the abdominal region greatly developed.

Its limbs must have been of proportionate size and strength to sustain and move so enormous a carcass; the hinder extremities, in all probability, resembled the unwieldy contour of those of the Hippopotamus or Rhinoceros, and were supported by strong, short feet, protected by broad ungual phalanges: the fore feet appear to have been less bulky, and adapted for seizing and pulling down the foliage and branches of trees; the jaws and teeth demonstrate its power of mastication, and the character of its food; while the remains of coniferous trees, arborescent ferns, and cycadeous plants, which are found imbedded with its remains, attest the nature of the flora adapted for its sustenance.

CHAPTER III.

PART VI.

WEALDEN REPTILES.

HYLÆOSAURUS—DISCOVERY OF THE FIRST SPECIMEN — CHARACTER OF THE SKELETON—DERMAL BONES—SPINES—SPECIMEN OF HYLÆOSAURUS FROM BOLNEY — HUMERUS AND SCAPULÆ — SPINAL COLUMN FROM TILGATE FOREST—VERTEBRÆ OF HYLÆOSAURUS — TOOTH OF HYLÆOSAURUS—MEGALOSAURUS — PELOROSAURUS — REGNOSAURUS—THE COUNTRY OF THE IGUANODON.

THE present section of this chapter will be devoted to the examination of the fossil remains of the other genera of saurians from the Wealden formation of the south-east of England, that are contained in this department of the national Museum.

The most remarkable of these extinct forms is the *Hylæosaurus,* or Wealden Lizard, of which there are three highly interesting specimens, which were formerly in my collection.

HYLÆOSAURUS OWENII.[1]—*Wall-case B : in the middle of the lowermost compartment.* (*ante,* p. 139.)—In the summer of 1832, upon visiting the quarry in Tilgate Forest, now familiar to my readers, I perceived traces of bones in some large masses of stone thrown on the road-side ; and on repairing to the quarry, found the workmen had put by other fragments for my inspection ; but the numerous pieces into which the original block of stone was now broken, the excessive hardness and refractory character of the grit, and the unpromising appearance of the few vestiges of bone that were visible, seemed to render it hopeless to obtain anything of interest. I resolved, however, to collect the scattered fragments, and after much labour, succeeded in cementing them together, and reducing the specimen to the state in which it now appears.

[1] From ὑλη, *sylva,* wood, *Weald,* or forest ; and *saurus,* lizard ; the WEALDEN LIZARD, or *Fossil Lizard of Tilgate Forest.*

It is $4\frac{1}{2}$ feet long, and 2 feet 3 inches broad at its widest extremity, but not more than two-thirds of the original mass remain; of the other third many pieces were lost, and those that were preserved could not be made to fit together. The portion of the skeleton displayed consists of the anterior part, or thoracic region, and comprises the following bones, namely :—

1st,—A series of ten vertebræ, five *cervical* (*Lign.* 66.-1), and five *dorsal* (2), adhering to the stone by their spinous processes; and of three other dorsal vertebræ, which are dislocated, but lie near to each other : there are, likewise, two detached dorsals in other parts of the block.

2dly,—Several ribs (3, 3), more or less displaced, situated on each side of the vertebral column.

3dly,—Near the end of the fifth dorsal vertebra, two *Coracoid* bones (6, 6).

4thly,—Two *Scapulæ* or *Omoplates* (7, 7).

These bones are somewhat displaced, the left coracoid overlying the right, and concealing one third of its sternal portion; in fact, the left scapula and coracoid appear as if they had been driven with great violence against the vertebral column, and over the opposite bone, and had occasioned the removal of the four dorsal vertebræ from their place.

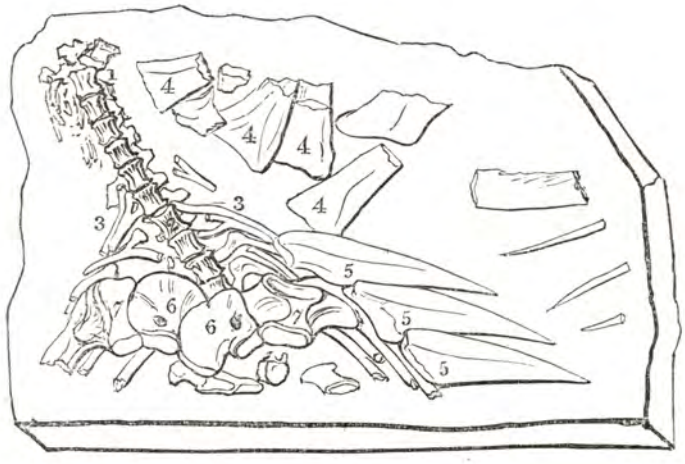
5thly,—On the left side of the column is a series of bony processes (4, 4, 4, 4), of the form of an isosceles triangle; they are irregularly disposed, yet seven of these are placed somewhat in a parallel line with the vertebral column; three of the largest, and most remarkable in form (5, 5, 5), lie near to each other, and in a direction at right angles with the former, and above the level of the coracoid bones.

Fragments of ribs and other bones, with two dermal osseous scutes, and here and there traces of lignite and vegetables, and casts of freshwater shells, are observable on the face of the stone which is presented to view.

On the opposite side (which it was necessary to place in cement), the ends of the spinous processes of the vertebræ were visible; and I found some interesting vegetable remains, and extracted a fine portion of the stem of Clathraria Lyellii, as well as several seed-vessels, which may have belonged to the same plant.

Thus the specimen before us consists of a considerable

number of the cervical and anterior dorsal vertebræ, eleven ribs, and the bones of the pectoral arch almost in juxtaposition; with numerous dermal scutes and spines; but there are no vestiges of the cranium, jaws, teeth, or bones of the extremities.



LIGN. 66. PART OF THE SKELETON OF THE HYLÆOSAURUS; FROM TILGATE FOREST.

(*Length of the specimen* 4½ *feet.*)

1. Cervical vertebræ.
2. Dorsal vertebræ.
3. Ribs: for the most part perfect and but little displaced.

4, 4, 4. &c. Dermal spines.

5. 5. 5. Three very large *Dorsal dermal Spines;* 15 inches in length.
6. 6. The *Coracoid* bones.
7. 7. The *Scapulæ;* the heads of these bones, united to the corresponding Coracoids, are the only parts seen.

Vertebræ.—"Of the cervical, the remains of five are recognisable. The compressed bony mass at the upper end of the spinal column, are probably the remains of two vertebræ; then follows one that is compressed, but its outline is defined. The succeeding vertebra is entire; it has two tubercles for the attachment of the costal processes, the transverse processes are short and very strong: this bone is 1·7 inch long and 2 inches wide.

The seventh cervical is much crushed; it has traces of the left lateral apophysis.

The first *dorsal* vertebra is entire, it is 2 inches long, and 2·2 inches wide at the extremities; it is depressed laterally,

"the anterior part of the body is rounded, the tubercle for the attachment of the rib well marked, and the transverse process short and strong: its rib is near it, and shows the deep bifurcation of the head, as in the Crocodiles.

The second, third, fourth and fifth dorsals succeed, and differ but little from each other; except that the third is more carinated; the fifth, which is $2\frac{1}{2}$ inches long, has its left rib near it; and the latter, unlike the four other ribs, has no strongly marked bifurcation, but its process sinks into a single head, as in the corresponding rib of the crocodile; and it is this character which, in the absence of other evidence, has been taken to determine the respective situations in the column to which the vertebræ belonged.

The second, third, fourth, fifth and sixth Ribs are seen on the left side of the vertebræ; on the right, the first, second and fourth only remain; the face of the sixth dorsal vertebra is shown beneath the sternal margin of the left coracoid, and one of its transverse processes appears near the fourth rib. The seventh, eighth, and ninth dorsals are displaced, and lie in a hollow formed by the extremities of the left ribs and the corresponding Coracoid. Another vertebra of the back, 2·8 inches long, (perhaps the tenth,) is thrown to the left side of the stone, and rests on portions of two ribs; the body is smooth and rounded, slightly arched, and its extremities, which are flat, are nearly circular, and two inches in diameter.

It is scarcely necessary to observe, that the ribs and vertebræ above described are decidedly of the fossil crocodilian structure; the union of the annular part by suture occurring, as M. Cuvier observes, in the living reptiles, in the crocodiles and turtles only; and if these bones were the only data from which to form an opinion of the nature of the original animal, we could not hesitate to assign it to some one of the fossil crocodiles mentioned in a former part of this Memoir. But the bones we have next to describe incontrovertibly prove that the animal could not have belonged even to the same family; and they afford another striking example of that union and blending, as it were, of different generic characters, which geology is constantly presenting to the comparative anatomist.

In the Crocodile, the sternum consists of a long, slender, flat bone, pointed both before and behind; and this is supported on each side of the middle of its lateral edges by

"a coracoid of an elongated form, which has a thick neck near the humeral extremity, that enlarges into a plane and wide portion, to attach itself to the sternum. The omoplate or scapula is not unlike the coracoid; its plane forms a narrow isosceles triangle; its neck is sub-cylindrical and curved internally, and widens to present a face to the coracoid: on the external edge of this is an articular apophysis, which with the corresponding one of the coracoid, forms the cavity for the reception of the head of the humerus. There are no traces of clavicles; the coracoid alone appearing to have formed a buttress against the sternum.

The *Scapulæ* of the Hylæosaurus, (*Lign.* 69, fig. 1,) correspond in many particulars with those of the Crocodiles above described, and unite with the Coracoids in a similar manner. The head of the bone is six inches wide, and very thick; it is contracted at the neck, and passes off into a flat and wide extremity: the articular facet is $2\frac{1}{2}$ inches high, and $3\frac{1}{2}$ wide. These bones are about twelve times larger than the scapulæ of a crocodile 3 feet long; they are marked 7, 7, in *Lign.* 66.

LIGN. 67.
CORACOID BONE OF THE HYLÆOSAURUS.
($\frac{1}{6}$ *nat. size.*)

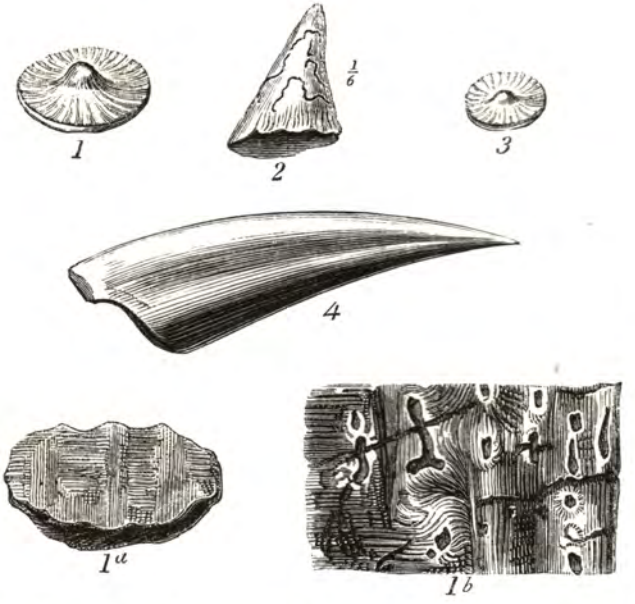
The *Coracoid bones*, (*Lign.* 66, 6, 6, and *Lign.* 67,) are entirely distinct from those of the Crocodile, and are like the coracoids of the true lizards, hatchet-shaped, but not emarginated; they have no apophyses corresponding with those of the recent Monitors and Iguanas, or the fossil Megalosaurus.

The longest diameter of the Coracoid is 7 inches; the transverse diameter 5·1 inch: it presents a large articular surface for the glenoid cavity, which is formed mutually by this bone and the scapula.

Near the neck of the bone there is a foramen for the passage of vessels, as is the case in the lizards, but not in the Plesiosaurus, Ichthyosaurus,[1] Megalosaurus, or Crocodile."

[1] I have seen an exception in a coracoid of an Ichthyosaurus, in which the humeral extremity throws off a kind of apophysis, that unites at the upper end of the glenoid cavity, and produces a foramen. The above account is extracted from my "Geology of the South-East of England."

DERMAL BONES.—Elliptical and circular dermal bones, having the under surface flat, and the upper convex with a conical tubercle, were first noticed in this specimen of the *Hylæosaurus;* I have since discovered similar scutes associated with other remains of this extraordinary reptile. (See *Lign.* 68, figs. 1, 3.)



LIGN. 68. DERMAL BONES OF REPTILES; FROM TILGATE FOREST.

Fig. 1, and 3.—Dermal scutes of the HYLÆOSAURUS: $\frac{1}{3}$ *nat. size.*

1a.—The under surface of a fragment of a *dermal bone*, displaying fine spicula, decussating each other at right angles, and indicating a similar structure to that of the *Corium: nat. size.*

1b.—A portion of the same, highly magnified, and viewed by transmitted light.

2.—HORN or DERMAL TUBERCLE, probably of the IGUANODON: $\frac{1}{6}$ *nat. size.*

4.—A DORSAL DERMAL SPINE of the HYLÆOSAURUS; the original is thirteen inches long.

The structure of these scutes is very remarkable; upon closely inspecting either the under side, or the surface exposed by a transverse fracture, very minute osseous spicula, decussating each other at right angles, are distinctly seen. (*Lign.* 68, fig. 1a.) In fig. 1b, a thin slice of a bone, magnified, and viewed by transmitted light, displays medullary canals, with very fine lines radiating from them. The peculiar character

of this organization consists in the disposition of the straight bony spicula; an appearance which first attracted my attention when chiselling away the stone, and led to the discovery of some perfect bones, that otherwise would have been destroyed. This structure closely resembles that presented by the ligamentous fibres of the *corium*, or skin, and seems to have resulted from an ossified condition of the dermal integument. These scutes vary from half an inch to three or four inches in diameter, and were, probably, disposed in longitudinal series on each side the spine, diminishing in size as they approached the tail.

Dermal Spines.—With the scutes above described there are associated in the specimen before us several flat, thin, angular, osseous plates, from three to seventeen inches in length, (one of these is figured *Lign.* 67, fig. 4.) The manner in which they are imbedded is shown in *Lign.* 66.

The probable nature of these spines was suggested in my original Memoir on the Hylæosaurus, as follows:—

"We have next to direct our attention to the triangular processes which lie on the left of the vertebral column, and three of which are very conspicuous near the base of the left scapula (marked 5, 5, 5, in *Lign.* 66). Of these bones there are no less than ten, more or less perfect, in different parts of the block; they vary in size from 5 to 17 inches in length, and from 3 to $7\frac{1}{2}$ inches in width at the base. The largest spine is 17 inches long, and $3\frac{1}{2}$ wide at six inches from the base, which is 4 inches thick; it differs somewhat in shape from the corresponding spines, and more nearly resembles one of the displaced bones. The middle process is $13\frac{1}{2}$ inches long, and 4·7 inches wide at the base, and is flat, and slightly depressed in the centre: the third is also very flat, and is 11 inches long. What the nature of these processes may be, it must be confessed is extremely problematical." After stating the objection to their being regarded as processes of vertebræ, or of ribs, it is observed that "another conjecture has occurred to me, and, extravagant as it may seem, appears to be the most probable. It is known that many of the lizards, particularly the Iguanas, have large cartilaginous processes with horny coverings, which form a sort of dermal fringe, or crest, along the back; in an animal 5 feet long, these spines are about an inch in height.

"Now the situation which the spines in the fossil occupy, is precisely that which the remains of such a dermal appendage would have been pressed into, if the carcass of the original animal had sunk down and become imbedded on its back, and the serrated dorsal integument squeezed to one side."[1]

Such were the reasons which led me nearly twenty years ago to ascribe these remarkable bones, then for the first time made known, to the dermal system of my newly discovered saurian.

In the "Brit. Assoc. Reports," 1841, Professor Owen, whilst admitting that "this ingenious suggestion carries with it a high degree of probability," points out objections to this hypothesis, and concludes that these singular bones are in all probability abdominal ribs; and referring to the great breadth of the abdominal as compared with the vertebral ribs in the Ornithorhynchus, observes that "after the close repetition in the Ichthyosaurus of another of the remarkable deviations in those aberrant mammals from the osteological type of their class, viz. in the structure of their sternal and scapular arch, the reappearance of the monotrematous modification of the sternal ribs in the present extinct reptile, would not be surprising.[2]

It was some years after Professor Owen's objection to my views had appeared, before I obtained a fragment of a dorsal spine for microscopical examination; but that test at once corroborated my original interpretation;[3] and in 1850, through the liberality of Mr. Peter Fuller of Lewes, I obtained a spine fifteen inches in length, with the corrugated depressed base entire; and which perfectly accords in its mode of implantation, as well as in its internal structure, with the dermal scutes of the Hylæosaurus and other reptiles. A model of this spine lies on the shelf to the right of the fossil represented in *Lign.* 66.[4]

The question, therefore, is now decided in the affirmative, and we have certain proof that in its dermal system the

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[1] "Geology of the South-East of England."

[2] "Report on Brit. Foss." 1841; p. 116.

[3] "Wonders of Geology;" 6th edit. vol. i. p. 437.

[4] See my memoir "On a Dorsal dermal Spine of the Hylæosaurus, recently discovered in the strata of Tilgate Forest."—"Philos. Trans." for 1850, p. 391, Pl. XXVII.

Hylæosaurus must have borne a general resemblance to the Cycluras, Iguanas, and other Lacertian reptiles, in which the appendages of the scaly integument are greatly developed. There can be no doubt that the back of this gigantic saurian was armed with a row of large angular spines covered by a thick horny investment.

Hylæosaurus from the Weald-Clay near Bolney.—*Wall-case B* (*ante*, p. 178).—The second specimen of the Hylæosaurus that came under my notice was discovered in a stratum of Weald clay, near the little hamlet of Bolney in Sussex, and unfortunately was sadly mutilated, and many of

1 2

Lign. 69.—Scapula and Humerus of the Hylæosaurus: from Bolney, Sussex.

1. The Scapula. 2. The Humerus.

($\frac{1}{8}$ *nat. size.*)

the bones destroyed by the labourers, before I was aware of the discovery, and could arrive at the spot to superintend their exhumation. From the relative proportions of the bones that I was enabled to collect, there is reason to conclude that they all belonged to the same skeleton. The principal specimens are placed on the shelves on each side the fossil

previously described, but the quantity collected was very considerable; there was, also, a large number of mutilated ribs, and of fragments of bones too imperfect to be deciphered. The following are worthy of notice :—

A perfect *Scapula* (*Lign.* 69, fig. 1), eighteen inches long, and the proximal or pectoral end of the corresponding bone.

One *Humerus*, sixteen inches long; this bone is perfect, and the radio-ulnar or distal articulation beautifully displayed (*Lign.* 69, fig. 2.).

A *phalangeal* bone of very abbreviated proportions.

Ribs : some are perfect, but several specimens show the well developed neck and tubercle for articulation with the vertebra.

A very peculiar character in some of these costal fragments, is the enormous expansion of the outer border of the rib, so as to constitute a wide plate, approaching to that of the Chelonian reptiles. This anomalous character may possibly have relation to the largely developed dermal appendages of the dorsal region.

SPINAL COLUMN OF THE HYLÆOSAURUS.—*Wall-case B.*—A third example of this saurian was brought to light in a quarry in Tilgate Forest, but a short time before I left Brighton, in the autumn of 1837. This fossil, like the former, fell into the hands of the parish labourers, who were unacquainted with the increased value of carefully extracted specimens. From the connected state of the vertebræ, even when first seen by me, it is certain that a much larger portion of the skeleton was imbedded in the rock, and might have been obtained with due care.

This most valuable specimen is placed immediately above that first described. It consists of three distinct portions of the spinal column, comprising twenty-five caudal vertebræ, which bear three distinct and peculiar modifications of the hæmapophyses.

Along each side of the vertebral column, there are several dermal bones of a circular or discoidal form, varying from one to three inches in diameter. There are likewise the bases of some very large angular dermal spines, analogous to those described in the first specimen (*ante, Lign.* 66). Thus while the scapulæ and ribs prove the generic relations between the first and second specimens, the dermal bones and vertebral column

yield evidence equally conclusive, that the last discovered fossil belongs to a reptile of the same genus.

VERTEBRÆ OF THE HYLÆOSAURUS.—It is remarkable that detached vertebræ of the Hylæosaurus are very rarely met with. In two of the specimens previously described, there is a considerable number of vertebræ but little removed from their natural juxtaposition: in the collection of detached bones from Bolney, but few remains of vertebræ were observed.

Fortunately, the state of integrity of the anterior, middle, and caudal regions of the spine, in the fossils alluded to, affords ample information as to the structure of the vertebral column in this remarkable genus of saurians.

The cervical and anterior dorsals are seen in the first discovered specimen, and the caudals in the fossil placed immediately over it.

In their general characters the vertebræ of the Hylæosaurus agree with those of the other Dinosaurians; there is the same vertical development and expansion of the neural arch and platform in the dorsals, but the bodies are somewhat shorter than in the Iguanodon, and both the articular facets are flat and nearly circular, not plano-concave and subelliptical, and contracted at the inferior part, as in that animal: there is a depression on each side of the base of the transverse process.

The cervicals, the visceral aspect of which is shown in the large specimen (*Lign.* 66), are somewhat flattened below and laterally, so as to present a quadrate form; and the transverse processes, and costal surface for the attachment of the ribs, are displayed; and several of the ribs are seen lying nearly in their original position. In the dorsal the visceral aspect forms an obtuse ridge, and this gradually becomes broader in the more distal vertebræ: the antero-posterior diameter of the longest dorsal is $2\frac{3}{4}$ inches.

SACRUM OF THE HYLÆOSAURUS.—*Wall-case C.*—Above the trays containing the large femora of the Iguanodon (*ante*, p. 237.1), the specimen on the extreme left of the remains of sacra there deposited is a portion of a pelvic arch, which is referred, with much probability, in "Brit. Assoc. Rep." (1841, p. 114), to the Hylæosaurus. This sacrum (labelled $\frac{484}{2484}$) consists of the bodies of two vertebræ, two inches

long, and parts of two others anchylosed together, with portions of the transposed neural arches. These vertebræ are more elongated than in the Iguanodon, and have the visceral aspect slightly furrowed. This fossil is minutely described in the work referred to.

But I have recently obtained a much finer specimen of this part of the skeleton of the Hylæosaurus, if, as I believe, Prof. Owen's determination of the fossil above described be correct. It consists of the bodies of four anchylosed sacral vertebræ, with portions of the hæmapophyses, and the medullary canal well defined. It was obtained by my friend Captain Lambart Brickenden, from the quarry in which the first known example of this saurian was discovered.[1]

As neither of the bones in this fossil appears to be a terminal one, it is probable that the sacrum of the Hylæosaurus, like that of the Iguanodon, consisted of six vertebræ. In the complete anchylosis of the bodies of the vertebræ, the position of the sacral ribs and neural laminæ, and the slightly sulcated visceral aspect of the bodies, it entirely accords with the fragment of a sacrum in the Case before us.

CAUDAL VERTEBRÆ OF THE HYLÆOSAURUS.—The structure of the caudal portion of the spine of this remarkable saurian is admirably shown in the fine series of twenty-six vertebræ from Tilgate Forest (*ante*, p. 323). This chain of bones comprises the base of the tail, and extends to a length of six feet; and though broken into three portions, and somewhat displaced, and the intermediate parts wanting, exhibits the various modifications of the vertebræ, and corresponding chevron-bones, which characterise the caudal region of the Hylæosaurus.

The anterior caudals are $2\frac{1}{4}$ inches in length, and have remarkably long and thick transverse processes, which proceed from the neural arch, and extend outwards and slightly forwards; the width of the tail at this part must have been from twelve to fourteen inches. A longitudinal furrow traverses the visceral aspect of these vertebræ, and is terminated at each end by two tubercles for articulation with the corresponding chevron bone, which is about five inches in length,

[1] This fossil is figured and described in "Philos. Trans." 1849, Pl. XXVII. p. 301.

and has two diverging and distinct processes of attachment, as in the crocodiles.

The bodies of the middle caudals are longer, narrower, sub-angular, and somewhat enlarged in the centre; they are $2\frac{3}{4}$ inches long, and $1\frac{1}{2}$ in vertical diameter. The transverse processes proceed from the centrum in these vertebræ, and gradually become less, till they are lost in the terminal caudals. The corresponding chevron bones are hatchet-shaped; the length, $1\frac{3}{4}$ inch, is equalled by the antero-posterior diameter of the distal expansion of the bone; the two laminæ unite at the proximal end, and form a distinct canal for the passage of the blood-vessels. The terminal caudal vertebræ are elongated, and have mere rudimentary processes; length of the body 2 inches, vertical diameter, $\frac{3}{4}$ of an inch. The chevron bone undergoes a corresponding change; its antero-posterior extent equals the length of the vertebra, but its vertical dimension is only $\frac{3}{4}$ of an inch: the contiguous hæmapophyses, therefore, meet in the centre of the body of each vertebra, a mechanism which conferred great strength and flexibility.[1]

The osteological characters here pointed out, show that the tail of the Hylæosaurus presented a striking contrast, in its form and construction, to that of the Iguanodon. Instead of being greatly developed in a vertical direction, the tail was broad and flat at the base, and gradually tapered off into a nearly cylindrical flexible chord, several feet in length.

Teeth of the Hylæosaurus?—No known vestiges of the cranium or jaws of this reptile have been discovered, nor any teeth that can with certainty be ascribed to it. Nevertheless, in the same strata with the remains of the skeletons previously described, there have been found several teeth of a peculiar character, which do not belong to the other species of reptiles whose remains are recognised in the same beds, and may in all probability be referred to the genus under consideration. These teeth are about $1\frac{3}{4}$ inch in height, and commence at the base with a cylindrical shank, which

[1] See "Philos. Trans." 1849, Pl. XXXII.: a lithograph, $\frac{1}{6}$ the natural size, of the specimen in the British Museum which exhibits this part of the spinal column of the Hylæosaurus.

gradually enlarges into a crown of an obtusely lanceolate form, convex in front, slightly depressed behind, and terminating in an angular rounded apex, the margins of which are generally more or less worn, as if from detrition (*Lign.* 70.). The crown is solid, but the fang encloses a small pulp-cavity; the surface is enamelled, and covered with very fine longitudinal striæ; the base in every specimen appears broken transversely, and has not a smooth surface, as if it had been loosened by absorption, and shed naturally. The fang never presents an appearance of lateral adhesion, as if it had belonged to a pleurodont lizard.

LIGN. 70.—TOOTH OF A REPTILE FROM TILGATE FOREST: PROBABLY OF THE HYLÆOSAURUS. *(nat. size.)*

Transverse sections of these teeth expose a simple, central, medullary canal, the upper part of which is generally filled with the ossified pulp; this is surrounded by a mass of firm dentine, with extremely minute calcigerous tubes radiating from the centre to the periphery of the tooth, that is invested with a relatively thick coat of enamel, in which no structure is apparent.[1]

The reference of these dental organs to the Hylæosaurus must not, however, be deemed conclusive, until confirmed by the discovery of similar teeth attached to a jaw, in connexion with other parts of the skeleton.[2]

The locomotive organs of the Hylæosaurus are but imperfectly known; a humerus, one phalangeal bone, and fragments of the fibula, are the only remains of the extremities that have come under my observation.

The Hylæosaurus, so far as the size and form of its body may be inferred from the remains of the skeletons hitherto discovered (for of its head and jaws nothing is at present known), probably attained a length of from twenty to thirty feet. The body was broader than high, and terminated in a long, slender, flexible tail; the limbs were relatively short; the skin was studded with scutes and tubercles; and a row of very large, thin, angular spines extended down the back, and

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[1] See "Medals of Creation," Pl. VI. fig. 6^{b}.

[2] "Phil. Trans." 1841, p. 144, Pl. VI. figs. 9, 10, 11.

formed a serrated dermal crest. The coracoids, scapulæ, and ribs, indicate a pectoral arch, in which were blended the osteological characters of the Monitors and Crocodilians.

MEGALOSAURUS BUCKLANDI.—*Wall-case A, lowermost shelf.* —The oolitic limestone of Stonesfield in Oxfordshire has long been celebrated for its fossil remains, and especially for the teeth and bones of a carnivorous reptile almost equal in bulk to the Iguanodon. Several teeth of this kind are figured in Lhwyd's "*Lithophylacii Brit. Ichn.*," but the description of the lower jaw with teeth, several vertebræ, and bones of the pectoral arch and extremities, by Dr. Buckland in 1824, ("*Geol. Trans.*" vol. i. new series), was the first scientific determination of the nature and relations of this reptile, which, from its gigantic dimensions, has been named the *Megalosaurus*. Before the publication of Dr. Buckland's memoir, similar teeth and bones had been discovered in Tilgate Forest, and were described in my "Fossils of the South Downs;" a work in which was first pointed out the general analogy between the fossil terrestrial animals and plants of Stonesfield, and Tilgate Forest.[1]

There are in the British Museum a considerable number of the teeth, and several bones of the Megalosaurus, from the Wealden of the South-East of England, but these specimens are not at present arranged with the reptilian remains under review. There are also some stupendous coracoid bones, part of a clavicle, and a femur, of the same species of reptile from Stonesfield, which are for the present deposited in Room II. Wall-case *C*.

In Room III. *Wall-case A*, there is placed on the lowermost shelf, a cast of the portion of the lower jaw in the possession of Dr. Buckland, which was presented to me by that eminent palæontologist. There is likewise a femur of the Megalosaurus from Tilgate Forest, in *Wall-case C*, (*ante*, p. 227,) and a portion of a large sacrum of this reptile, from Stonesfield.

The osteological characters of the known parts of the Megalosaurus are so fully described and illustrated in Dr. Buckland's "Bridgewater Treatise," (Pl. XXIII. p. 234), that a brief notice only is requisite.

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[1] "Illustrations of the Geology of Sussex," p. 59.

The specimen of the lower jaw from which the cast in Wall-case *A* was taken, consists of a portion of the dentary bone, 11 inches long, and $3\frac{1}{2}$ inches vertically; it contains one perfect tooth, 3 inches high and 1 inch wide, and the germs of several others. The tooth has a conical, laterally compressed crown, resembling a sabre with the point curved backwards; the edges are trenchant and finely serrated. It is composed of a central body of dentine, the crown having a coating of enamel, and the whole an external investment of cement, which forms a thicker layer around the fang; the pulp-cavity is occupied by coarse bone in the adult tooth. The microscopical examination shows the dentine to consist of very fine calcigerous tubes, $\frac{1}{28,000}$th of an inch in diameter, without any admixture of medullary canals, radiating from the pulp-cavity at right angles with the external surface of the tooth, and sending off numerous secondary branches; these ultimately dilate into, or inosculate with, a stratum of calcigerous cells that separates the dentine from the enamel.[1]

LIGN. 71. TOOTH OF THE MEGALOSAURUS BUCKLANDI. (*nat. size.*)

The implantation of the teeth is very peculiar, and exhibits the dentition of the Crocodilians blended with that of the Lacertians. The jaw has an outward parapet, as in the true lizards, but the teeth are fixed in distinct sockets, formed by transverse partitions, that are attached to a mesial, or inner parapet, composed of a series of triangular osseous plates; the bases of the old teeth, and the germs of the new ones, being thus enclosed and concealed.

The form of the lower jaw is but imperfectly revealed in this unique specimen; it seems to have been very much compressed laterally, so that the original animal must have had a very narrow and acute muzzle, strikingly contrasting with that of its colossal herbivorous contemporary.

The *Sacrum* of the Megalosaurus is composed of five (six?) anchylosed vertebræ; and of this part of the skeleton four

[1] "Odontography," p. 271. See also "Medals of Creation," Pl. VI. fig. 7.

examples, more or less entire, have been collected.[1] The first discovered specimen, which clearly demonstrates the peculiar construction of the sacrum, is figured and described by Dr. Buckland: a portion of a sacrum from Stonesfield, in Wall-case *C*, is the only example in the British Museum.

The *Vertebræ* have the same remarkable development of the neural arch and platform as in the Iguanodon, but the bodies are rounded, not laterally compressed; and there are other obvious differences.

The *Coracoids* differ entirely from those of the Iguanodon and Hylæosaurus, and closely resemble the corresponding bones in the Monitors. The *Clavicle* bears considerable analogy to that of the Iguanodon.

The *Femur* is easily recognised by two large rounded trochanters of nearly equal size below the head of the bone: its shaft, which like that of the Iguanodon has a large medullary cavity, is subcylindrical and slightly arched. There is a model of a metatarsal or metacarpal bone, twelve inches long, in Wall-case *A*: the original is in the museum at Oxford.

The decided trenchant character of the teeth leaves no doubt that the Megalosaurus was highly carnivorous; it appears to have been a terrestrial animal, and probably preyed on the smaller reptiles, and on the young of the colossal Iguanodon, Hylæosaurus, and others of its contemporaries.

Pelorosaurus[2] Conybearei.—*Wall-case C.*—In the lowermost compartment on the left side of this case there are four very large and remarkably perfect caudal vertebræ, of a rich umber colour, and though completely petrified, the neural arch, and the lateral processes, are almost as perfect as when the bones were recent. These magnificent fossils were promiscuously imbedded in a block of fawn-coloured sandstone in Cuckfield Quarry, together with the bifurcated chevron bone, and the two detached processes, placed above them. I chiselled away the sandstone, extricated the vertebræ, and succeeded in developing them in their present perfect condition. When first obtained I ascribed them to the Iguanodon; in fact, every large bone found in the same quarry was natu-

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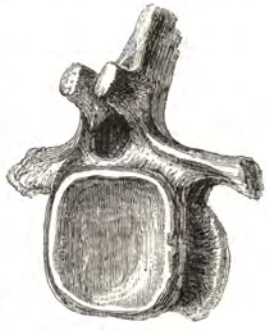
[1] See "Brit. Assoc. Rep. Foss. Reptiles," 1841, p. 105.

[2] *Pelorosaurus;* from Πέλωρ, *pelor*, monstrous, or unusually gigantic.

rally referred to that stupendous creature; for it was not supposed that the remains of several genera of gigantic reptiles were entombed in those previously unproductive deposits.

These vertebræ are distinguished by their great size and extreme shortness; the antero-posterior diameter of the body being but little more than three inches, and the transverse diameter of the articular face upwards of seven inches. They are doubly concave; the anterior face being the most depressed. They were ascribed by Professor Owen, ("Brit. Assoc. Reports," 1841, p. 101,) to a genus of marine saurians, whose vertebræ and other parts of the skeleton occur in the Oolitic deposits; and which, from the presumed general resemblance to the cetaceans in the short, doubly concave vertebræ, and the solid bones and natatory character of the extremities, has been named *Cetiosaurus:* the present vertebræ being described as a new species,—*Cetiosaurus brevis.*



LIGN. 72.
VERTEBRA OF THE PELOROSAURUS CONYBEAREI.
Anterior aspect.
($\frac{1}{8}$ *nat. size.*)

Referring the scientific inquirer to "Philos. Trans." 1849, for the considerations which led Dr. Melville and myself to question the correctness of this determination, it will only be necessary to state that these vertebræ are remarkably distinguished by the entire absence of projecting posterior articular processes, or zygapophyses. The base of the neural spine has on the posterior part a deep depression on each side, and the anterior processes extend over the body of the vertebra, and are articulated to the corresponding surfaces of the spinous process of the contiguous bone.

The following are the dimensions of the largest vertebra:—

Antero-posterior diameter of the body . .	$3\frac{1}{2}$ inches.
Transverse diameter	$7\frac{1}{2}$
Vertical diameter of the anterior face . . .	$6\frac{3}{4}$
——————— posterior „ . . .	6
Height to the top of the spinous process . .	13
Diameter of the neural canal	2

The general resemblance of these caudals to two vertebræ found at Honfleur, struck me when I first discovered them; but the latter appear to be generically distinct; they are figured

and described by Baron Cuvier, ("*Oss. Foss.*" tome v. Pl. XXII. figs. 1 & 2, p. 352,) as follows :—

"Corps cylindrique, presque aussi long que large, marqué de chaque côté d'une petite fossette, à faces planes, circulaires, à canal médullaire fort étroit, à partie annulaire non articulée ; l'apophyse épineuse, haute, et droite ; les transverses au niveau du canal médullaire, grosses, cylindriques, dilatées verticalement au bout ; et, ce qui est très remarquable, *les articulaires postérieures petites*, pointues, rapprochées, et donnant dans deux petites fossettes entre les antérieures et au-devant de la basse de l'épineuse."

In the autumn of the year 1849, I obtained from Mr. Peter Fuller, of Lewes, the most stupendous humerus of a terrestrial reptile ever discovered ; it is $4\frac{1}{2}$ feet in length, and 32 inches in circumference at the distal end. It was found in the Iguanodon quarry near Cuckfield, in the bed of sandstone whence the gigantic vertebræ under examination were exhumed ;[1] and two distal caudals, with the same remarkable character of the zygapophyses, have since been obtained. It appears to me highly probable that the gigantic bone of the fore-limb and these vertebræ, belonged to the same genus of terrestrial saurians ; and as the vertebræ are unquestionably distinct from those of the *Cetiosauri*, I would provisionally assign them to the new genus Pelorosaurus ; for I have obtained dorsal vertebræ, chevron-bones, coracoids, and scapulæ, which prove that the original animal is referable to the Dinosaurian order, as characterised by a sacrum composed of five or six anchylosed bones, and vertebræ with high and expanded neurapophyses like the Iguanodon and Megalosaurus.

These vertebræ are distinguished by the subquadrangular form of the articular facets, and the shortness of the antero-posterior diameter of the bodies. They are slightly concave in front, and almost flat behind, the upper part of the anterior face being the deepest : the sides of the body are concave, both lengthwise and vertically, with a tranverse median convexity.

The inferior surface of the centrum is slightly concave

[1] See "Memoir on the *Pelorosaurus*, an undescribed gigantic terrestrial reptile, whose remains are associated with those of the Iguanodon, in the strata of Tilgate Forest." "Philos. Trans." 1850, p. 379. See APPENDIX—H.

in its antero-posterior diameter, and divided by a longitudinal depression, whose termination obscurely indicates the position of the hæmapophysial articulations; but it must be remarked that no unequivocal surfaces for the attachment of the chevron-bone are apparent.

The neural arch is large, and anchylosed to the anterior half of the upper surface of the centrum, the posterior part of which is left free. The anterior zygapophyses project directly forwards, and advance over the exposed part of the body of the contiguous vertebræ, and articulate with the depressions on each side the spinous process. The transverse processes are very strong and short, and project at nearly right angles from the body. The spinous process is short and thick.

These four vertebræ are placed on the shelf in a consecutive line, but it is doubtful whether the two right hand bones are in their natural order; it seems probable that there was an intermediate vertebra between the second and third, and between the third and fourth, so that two more would be required to complete the series.[1]

The chevron-bone found in the same block, and suspended above the vertebræ,[2] is obviously too small for articulation with either of the above; it is, however, important, as showing the crocodilian modification of the process, if this bone belonged to the same species of reptile; but that is doubtful, for chevron-bones found with similar vertebræ in the Isle of Wight, have the head confluent, as in the corresponding element of the Iguanodon.[3]

REGNOSAURUS NORTHAMPTONI.—*Wall-case C.*—A portion of the right side of the lower jaw of a lacertian reptile, placed on the narrow front shelf in this case (*see ante, p.* 227), although a mere fragment, and destitute of the crowns of the teeth, is highly interesting, because it unequivocally indicates a genus

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[1] See figures and descriptions of these fossils in "Phil. Trans.," 1850, p. 381, Pl. XXII. XXIV. XXV.

[2] Ibid. Pl. XXII. fig. 8.

[3] *Cetiosaurus.*—Professor Owen ascribes a few other vertebræ from the Wealden, which are deposited in this case, to the genus Cetiosaurus; but as no bones of the extremities of strictly aquatic saurians have been found in the strata of the Wealden, it appears more probable that these remains of the spinal column are referable to other genera.

of reptiles distinct from the Megalosaurus, Iguanodon, Goniopholis, and other saurians, whose maxillary organs are known. Before the jaw of the Iguanodon was recognised, I thought it probable this fragment might belong to a species of that genus, and under this impression, I communicated a description, with figures, to the Royal Society, in 1841.[1] Professor Owen ("Brit. Assoc. Reports," 1842) expressed his opinion that the fossil in question might, with greater reason, be ascribed to the Hylæosaurus. Subsequent observations have led me to conclude that it is generically distinct, and in my Memoir on the Jaw of the Iguanodon ("*Phil. Trans.*" 1848, p. 183), I proposed to distinguish the reptile to which it belongs by the name of *Regnosaurus*,[2] with the specific appellation *Northamptoni*, as a tribute of the highest respect and regard to my deeply lamented friend the late noble President of the Royal Society.

This specimen is a portion of the right side of the lower jaw, three inches in length, and $1\frac{3}{5}$ of an inch in the vertical direction, at the proximal end. It consists of the middle portion of the dentary bone, and the distal part of the opercular. It contains the lower third of the fangs of fifteen teeth, and the imprints of three others, with indications of the germs of four successional teeth. The fangs are cylindrical, $\frac{1}{8}$ of an inch in diameter, and six occupy the space of one inch; all the crowns are broken off, some close to the margin of the parapet, others low down in the socket; and this must have taken place before the jaw was imbedded in the strata, for the sandstone filled up all the sockets, and there were no traces of teeth in the surrounding block. The dentary bone forms a strong parapet; its inner aspect is deeply sculptured with the alveoli, to which the fangs of the teeth are anchylosed, in the same manner as in the Iguanas; but the partitions which separate the teeth are very regular: the germs occupy the same relative position at the base of the mature teeth as in those reptiles. There are indications of a thin mesial alveolar process, but its extent cannot be determined, and it seems probable that the fangs of

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[1] "Phil. Trans.," 1841, Pl. V. p. 131.

[2] *Sussex Saurian.*—The County of Sussex was anciently inhabited by the *Regni*.

the teeth had no osseous protection on the inner side, and were not implanted in complete sockets, but simply covered by the germ as in the existing lizards. The upper margin of the alveolar parapet is regularly scalloped by the termination of the dental sockets, and presents a convex outline, which gently bends towards the front of the jaw; the same part is straight in the corresponding space of the jaw of the Iguanodon. A few small vascular foramina issue below the alveolar ridge; the external surface of the bone is minutely striated and punctated. The fractured proximal end displays the opercular furrow, and the canal for the maxillary vessels and nerves; the anterior, or apical extremity is solid.

The opercular bone was evidently of a rhomboidal form, and extended but a short distance over the dentary; it has two vascular perforations; characters which correspond with those of the Iguana.

The well-marked generic difference between this maxillary organ and that of the Iguanodon, will be obvious upon comparing the above description with the figures *Lign.* 53 and 54, *ante*, p. 245.

For the arguments in support of the reference of this jaw to the Hylæosaurus, the reader should consult the "Reports on British Fossil Reptiles," 1842, p. 119; to me they do not appear conclusive, for this jaw clearly belonged to an adult reptile, very much smaller than the Hylæosaurus; and the teeth of the latter are not positively ascertained. In the hope of determining the question by the microscope, Mr. Tomes kindly examined a portion of a tooth for me, but without decisive results: for as the fang was the only part remaining, its structure afforded no evidence as to the nature of the dentine of the coronal portion; I could only ascertain that, as compared with the fang of the tooth conjectured to belong to the Hylæosaurus, (*Lign.* 70, *ante*, p. 327,) it presented a much coarser osseous tissue. Under these circumstances, I conceive it desirable to retain a distinct generic appellative for this remarkable specimen, until further discoveries reveal its true character and relations.[1]

THE COUNTRY OF THE IGUANODON.—We have now exa-

[1] APPENDIX I. Notice of the Author's collection of Organic Remains now in the British Museum.

mined the principal specimens of the terrestrial plants and animals of the Wealden formation of the south-east of England, that are contained in the British Museum, and I will conclude this section of the present chapter with some general remarks on the physical geography, and the nature of the fauna and flora, of the Country inhabited by the stupendous reptiles, whose fossil remains have so long engaged our attention.

From the nature of the alluvial sediments accumulated in the lapse of innumerable ages in the deltas and estuaries, which now constitute a great part of the area of the south-east of England, and of the north of Germany, a general idea may be obtained of the aspect of the country through which the river flowed, and the character of the superficial strata; and from the fossil remains we may learn the nature of the trees and plants which clothed its soil, and of the animals that roamed over the land, or inhabited the waters.

Whether that country were an Island or a Continent cannot be determined; but that it was diversified by hills and valleys, and irrigated by streams and rivers, and enjoyed a climate of a higher temperature than any part of modern Europe, is most evident. Coniferous trees in all probability clothed its alpine regions; palms, arborescent ferns, and cycadeous plants, constituted the groves and forests of its plains and valleys; and in its fens and marshes the equisetaceæ, and plants of a like nature, prevailed. That the soil was of a sandy character on the hills and elevated grounds, and argillaceous in the plains and marshes, may be inferred from the vegetable remains, and the materials in which they are imbedded. Sands and clays every where prevail throughout the Wealden formation, and have probably resulted from the decomposition of micaceous and felspathic rocks.

Some inferences also may be drawn as to the prevailing atmospheric condition of the country, from the undulated surfaces of the laminated sandstones and shales, and from the stems of the fossil trees. In the former we have proof, that when the land of the Iguanodon existed, the water was rippled by the breezes which then, as now, varied in intensity and direction in a brief space: from the latter we learn that in certain situations the wind blew from a particular quarter for a great part of the year, and that the mean annual temperature was as variable as in modern times.

If we attempt to portray the vertebrated animals of that unknown country, our description will partake more of the character of a romance of the fabulous ages, than of a legitimate deduction from established facts. Turtles of various kinds must have been seen on the banks and in the waters of its rivers and lakes, and groups of enormous crocodiles basking in its fens and marshes. The colossal Megalosaurus and Pelorosaurus, and yet more marvellous Iguanodon, to whom the groves of clathrariæ and arborescent ferns would be mere beds of reeds, must have been of such prodigious magnitude, that the existing animal creation presents us with no fit objects of comparison. Imagine an animal of the lizard tribe, three or four times as large as the largest alligator, with jaws and teeth equal in size to those of the rhinoceros, and with legs as massive in their proportions as the limbs of the elephant—such a creature must have been the Iguanodon.

From what has been advanced, it must not, however, be supposed, that the country of the Iguanodon occupied the site of the South-East of England, and that the animals and terrestrial plants of the Wealden lived and died near the area where their relics are entombed; for, with the exception of the shells and crustaceans, and certain marsh and aquatic plants, all the fossil remains bear unequivocal marks of having been transported from a great distance. But though three-fourths of the bones discovered have evidently been broken and rolled before their deposition, the teeth detached from their sockets, the vertebræ, and the bones of the extremities, with but very few exceptions, disjointed and scattered here and there, the stems and branches of the trees torn to pieces and stripped of their foliage,—there is no intermixture of sea-shells, nor of beach or shingle: these remains have been subjected to abrasion from river currents, but not to attrition from the waves of the ocean.

The gigantic limbs of the large saurians could not have been dissevered from their sockets without great violence, except by the decomposition of their tendons from long maceration in water; and if the latter were alone the cause of the dislocation of the bones, we should not find them broken and waterworn, but lying more or less in juxtaposition, as is the case in the skeletons of the marine reptiles of the liassic deposits. But the condition in which the fossil relics of the

Wealden occur, proves that they were floated down the streams and rivers, with rafts of trees and other spoils of the land, till, arrested in their course, they sank down and became buried in the fluviatile sediments then in progress.

The state of the first discovered specimen of the *Hylæosaurus* is in this point of view highly instructive: many of the bones are crushed and splintered, yet the fractured portions remain near each other; the vertebræ are more or less displaced, yet they maintain relation to the positions they originally occupied; the bones of the fore-legs have been torn from their sockets, and this must have taken place before the specimen was imbedded in the mud and sand, for the glenoid cavities were filled with stone: these facts prove that the carcass of the original must have undergone mutilation before the bones were reduced to a skeleton; and that the dislocated and broken parts were held together by the muscles and integuments; in this state the trunk was borne down the stream, and at length sank into the mud of the delta, and formed a nucleus around which the stems and leaves of cycadeous plants and ferns were accumulated, and river shells became intermingled in the general mass.

The phenomena here contemplated cannot, I conceive, be satisfactorily explained upon any other supposition than that which implies a long transport, by the agency of streams and currents: the carcasses of the colossal reptiles must have been exposed to such an action for a considerable time, and the source of the mighty river which flowed through the Country of the Iguanodon, must, therefore, like that of the Mississippi, have been far distant from the delta which in the course of innumerable ages accumulated at its mouth.[1]

[1] See "Wonders of Geology," p. 444, and pp. 483—490.

CHAPTER III.

PART VII.

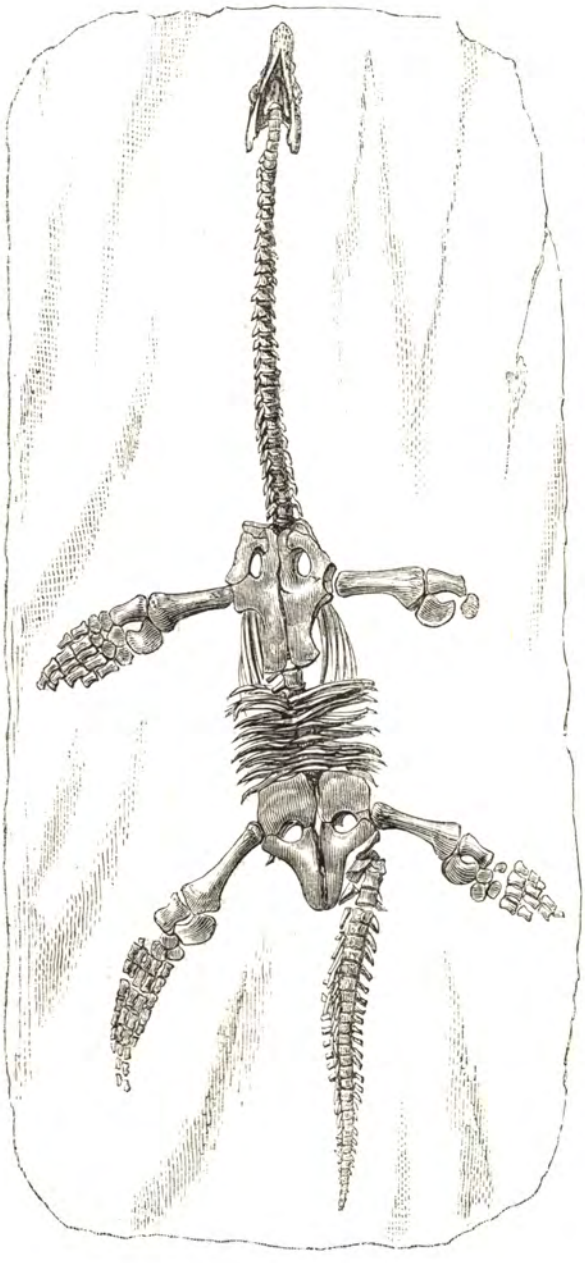
THE PLESIOSAURI.

ENALIOSAURIANS—STRUCTURE OF THE PLESIOSAURUS—DISCOVERY OF THE PLESIOSAURUS DOLICHODEIRUS BY MR. CONYBEARE—HABITS OF THE PLESIOSAURI — PLESIOSAURUS HAWKINSII — PLESIOSAURUS ARCUATUS — PLESIOSAURUS MACROCEPHALUS—PLESIOSAURUS RUGOSUS—PLESIOSAURI OF THE WEALDEN.

ENALIOSAURIANS.—As in the tertiary and modern epochs, the predominant terrestrial vertebrata, the mammalia, were represented by aquatic forms of gigantic size which inhabited the sea, so also during the "Age of Reptiles," types of the prevailing class of land quadrupeds swarmed in the ocean, and equalled in numbers, and almost in magnitude, the cetaceans of the present day. These reptilian denizens of the seas of the secondary ages, constitute the order *Enaliosauria*, (*i.e.* marine saurians,) which comprises two principal groups; namely, the *Ichthyosauri*, or fish-like lizards; and the *Plesiosauri*, which, as the name implies, are more nearly allied to the saurians than the animals of the former division; both were air-breathing, cold-blooded, carnivorous, vertebrate animals, with two pairs of natatory extremities. The Plesiosauri first claim our attention, because the specimens of this genus are deposited in the cases of the Room at present under survey.[1]

The perfect skeletons which will now engage the visitor's attention, present a remarkable contrast with the isolated and

[1] Dr. Buckland's "Bridgewater Treatise" contains an admirable exposition of their habits and organization; and "Brit. Assoc. Rep." 1839, an elaborate osteological investigation of both genera.



LIGN. 73. PLESIOSAURUS HAWKINSII; FROM THE LIAS STRATA, SOMERSETSHIRE. ($\frac{1}{10}$ *nat. size.*)

fractured bones and waterworn relics of the terrestrial reptiles whose remains formed the subject of the previous section of this chapter. The beautiful state of preservation of many of the Plesiosauri,—the entire skeleton, from the point of the muzzle to the extremity of the tail, lying in relief, as if it had sunk down quietly on the soft clay, and become petrified on the spot,—manifests how different were the conditions in which the strata of the Lias and the Wealden were deposited; while the exquisite manner in which the investing stone has been removed, attests the consummate skill and indefatigable zeal of the gentleman by whom these superb fossils were developed.[1]

I shall reserve for the next chapter an account of the circumstances under which the matchless series of Enaliosaurian remains in our National Museum were obtained; and restrict my remarks to the description of the individual specimens in the *Wall-cases D, E,* and *F,* of this Room; those in Case *D* are arranged as under :—

WALL-CASE D. [4.]

Original specimen of Plesiosaurus dolichodeirus. (Rev. W. D. Conybeare, "Geol. Trans." vol. i. Pl. XVIII. | *Top.*

Plesiosaurus Hawkinsii.—Pl. XXIV. of Mr. Hawkins's work.

Bones of the Plesiosaurus arcuatus.	Plesiosaurus dolichodeirus: the under surface of lower jaw exposed, and two paddles on the right side.	Bones of the Plesiosaurus arcuatus.

PLESIOSAURUS.—The animals of this genus present in their osteological structure a remarkable deviation from all known recent and fossil reptiles; uniting the characters of the head of a lizard, with the teeth of a crocodile, to a neck of inordinate length, and with such modifications of the ribs, the pectoral and pelvic arches, and the paddles, as to justify the graphic simile of an eloquent Professor, that the Plesiosaurus might be compared to a serpent threaded through the shell of a turtle.

The character which immediately strikes the observer, is

[1] Thomas Hawkins, Esq. The splendid volume of this gentleman on these marine saurians cannot fail to delight the reader by its graphic descriptions, and beautiful illustrations. See APPENDIX K, Mr. Hawkins's Collection of Enaliosauria.

the extraordinary length of the neck, and the relative smallness of the head. The neck, which in most animals is formed of but five vertebræ, and in the extremest recent example, the Swan, does not exceed twenty-four, is in certain species of Plesiosaurus composed of from twenty to forty vertebræ, and is four times as long as the head, and equal in longitudinal extent to the body and tail; while the length of the head (in *P. dolichodeirus*) is less than one-thirteenth of the entire skeleton; the tail is very short.

The skull resembles that of the Crocodiles in its general form, but is proportionately smaller; the breathing apertures are situated anterior to the orbits, on the highest part of the head. The orbit is relatively large, and furnished with a zone of bony plates, as in the sclerotica of certain lizards and birds.[1] The lower jaw has the usual structure of the saurians; but the dentary bone is greatly expanded anteriorly, and united in front.

The teeth are implanted in separate sockets, and there are from thirty to forty on each side the jaws. They are conical, slender, long, pointed, slightly recurved, and longitudinally grooved from the base upwards, and have a long round fang. The pulp-cavity is long and simple, surrounded by a body of firm dentine, covered on the crown with a layer of enamel, and at the base with cement. The dentition in the Plesiosauri differs from that of the Crocodiles, in the successional teeth emerging through distinct apertures on the inner side of the sockets of their predecessors, and not through the pulp-cavity.[2] The vertebræ are relatively longer than in the Ichthyosaurus, and their articular faces are either flat, or slightly excavated towards the periphery, with a gentle convexity in the centre.

The *Pectoral arch* is remarkable for the greatly elongated and broad *Coracoid* bones. The *Ribs*, which are very numerous, and extend throughout a great portion of the vertebral column, are connected, anteriorly, by slender bones; the Ichthyosaurus has a similar structure. As these connecting parts are so constructed as to admit of a certain degree of gliding motion upon each other, it is inferred that consi-

[1] See Dr. Buckland's "Bridgewater Essay," Pl. X.
[2] See Professor Owen's "*Odontography*," p. 282.

derable expansion of the pulmonary cavities took place in these air-breathing marine lizards.

The bodies of the vertebræ are subcylindrical, and their articular surfaces nearly flat; there are two pits on the under part; the hæmapophyses and costal processes are not anchylosed to the body; and the hæmapophyses consist of two distinct laminæ which do not coalesce distally into a spine, and form a true chevron-bone.[1]

The paddles are composed of fewer and more slender bones than in the Ichthyosaurus, and must have been of a more elegant form, and of greater flexibility. The carpus consists of a double row of round ossicles, which are succeeded by elongated metacarpals, and these by slender and slightly-curved phalangeal bones.

PLESIOSAURUS DOLICHODEIRUS.—*Wall-case D.*—The specimen on the top of this Case is invested with a classical interest, for it was the subject of the admirable Memoir on this remarkable genus by the present Dean of Llandaff, (the Rev. W. D. Conybeare,) on the *Plesiosaurus dolichodeirus* (*long-necked*), read before the Geological Society, Feb. 20, 1824, and published in the "Geol. Trans." vol. i. *New Series.*[2] In the Case below, there is another specimen of the same species from Lyme Regis; it is nine feet in length, has the two right paddles, and exhibits the under surface of the lower jaw. A third specimen of this species, consisting of the trunk and paddles, is deposited in the upper compartment of Case *F*.

This species presents such extraordinary deviations from the ordinary saurian type, in the great length of its neck, and the extreme smallness of the head, that the correct interpretation of its characters and affinities, at the dawn of

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[1] For anatomical details consult "Brit. Assoc Report," 1839.

[2] This specimen is figured in "Geol. Trans." vol. i. new series, Pl. XLVIII. p. 381. It was discovered and developed by the late Mary Anning, of Lyme Regis, and purchased by the late Duke of Buckingham for (I believe) 105*l*. I had the pleasure of being present when Mr. Conybeare read the Memoir at the meeting of the Geological Society in Bedford Street, Covent Garden; the specimen was placed in the narrow vestibule at the entrance, for want of room. Some years afterwards I saw it, in company with Dr. Buckland, at the princely mansion of the Duke of Buckingham, at Stowe. On the dispersion of the treasures of nature and art in that noble collection, it was bought for the British Museum.

British Palæontology, attests in a striking manner the sagacity, and consummate skill, and profound knowledge of the Cuvierian philosophy, of our eminent countryman, the Rev. W. D. Conybeare.

In the first specimen, the cranium and jaws are somewhat crushed; of the vertebral column, a great portion of the cervical and caudal regions has the bones in connexion; but the dorsals are much dislocated, and the ribs displayed. The anterior right, and the left hinder extremity, are almost entire: the corresponding paddles are imperfect, and somewhat displaced. The pectoral arch is not seen, but the "*sterno-costal-arcs*," that protected the abdomen, are perceptible. Of the pelvis, the principal bones remain; the caudal vertebræ and their hæmapophyses are beautifully shown.

A good idea of the general form of the living Plesiosaurus is conveyed by this fine specimen; and the correctness of the restoration of the entire skeleton given by Mr. Conybeare, (Pl. XLIX. of the same vol.) has been established by subsequent discoveries, and especially by the perfect examples which the researches of Mr. Hawkins have brought to light. I subjoin a few remarks from the original Memoir, and some additional details of the structure of these marine saurians.

"The neck is fully equal in length to the body and tail united; and which, surpassing in the number of its vertebræ that of the longest-necked birds, even the Swan, deviates from the laws which were heretofore regarded as universal in quadrupedal animals and the cetacea. The whole vertebral column numbers about 90 joints, *viz.* 35 cervical, 6 anterior dorsal, 21 dorsal and lumbar, 2 sacral, and 26 caudal. The proportion of these parts will stand nearly thus; taking the head as 1, the neck will be 5, the body 4, and the tail 3: the whole length being 13 times that of the head.

"The general proportions of the *Tortoise*, its length of neck, shortness of tail, and the smallness of its head, are in some degree analogous to what we observe in the Plesiosaurus; but the structure of the head and teeth of the latter, and its want of shell, entirely negative the idea of its being intimately allied to the chelonians, and decidedly connect it with the saurian order."

The vertebræ are recognised by their nearly flat articular facets, and the presence of two small vascular pits on the

inferior aspect of the centrum; and they are rather wider than long. The annular part is united to the body by suture, but not anchylosed to it. The spinous process is rather elevated; the posterior zygapophyses are higher than the anterior, and rest almost horizontally on those of the contiguous vertebræ.

The anterior cervical vertebræ support small ribs, which are articulated by two tubercles, and terminate in a hatchet-form, like the analogous elements in the Crocodile. In the six succeeding vertebræ, the ribs are elongated, and assume by degrees the form of the dorsal costal-processes.

The vertebræ of the tail are distinguished by the small facets for the hæmapophyses, which, as in the crocodiles, are articulated between the junction of two vertebræ, so that there are two articular depressions for each of the laminæ, the centrum having four, viz. two at the anterior edge and two at the posterior; the transverse processes of the caudals are attached by suture as in the young crocodile.

The humero-pectoral arch in the Plesiosaurus is very remarkable for the great size, and antero-posterior expansion of the coracoids, (see *Lign.* 73).

The structure of the ribs is also peculiar; for each pair of costal processes formed an osseous cincture, which encircled the body, and was composed of five distinct parts; namely, the two spinal, which were articulated to the centrum by a bifurcated head; and three slender vertical bones that were fitted to one another by oblique grooves; the median piece being transversely elongated, and slightly curved and pointed at both extremities; these intermediate processes are termed by Mr. Conybeare the "*sterno-costal arcs;*" a similar structure exists in the Chameleons and certain species of Iguanas. This mechanism admits of great expansion of the abdominal muscles and integuments during the inflation of the lungs; and hence M. Cuvier suggested the probability that the pulmonary organs in the Plesiosaurus were very large, and that this marine saurian, like the Chameleon, changed the colour of its skin according to the varied intensity of its respiration.

The principal bones of the anterior extremities, or paddles, consist of the usual normal elements, *viz.* a humerus, radius, and ulna; the first is a stout bone, with a rounded head, and

has the distal extremity expanded to articulate with the short flat bones of the fore-arm ; the carpus or wrist is composed of a double row of from six to eight discoidal ossicula, which support the slender elongated metacarpals, that articulate with the digital or phalangeal bones ; the latter are connected by flattened surfaces. The entire series of bones was, doubtless, enveloped in one common integument, in like manner as the paddles of the cetacea.

The pelvis, which is well shown in the specimen before us, consists of strong and short *iliac*, and broad *pubic* and *ischiac* bones ; the two latter being expanded in the antero-posterior direction, like the coracoids.

The hinder paddles are very similar in their construction to the anterior, which they equal in size.

Physiological Inferences.—Mr. Conybeare concludes his admirable memoir with the following general remarks on the habits and economy of this tribe of marine saurians :—

"In its progression the Plesiosaurus must have more nearly resembled the Turtles than any other reptiles. That it was aquatic is evident from the form of its paddles ; that it was marine is almost equally so from the remains with which its bones are universally associated ;[1] that it may have occasionally visited the shore, the resemblance of its extremities to those of the turtle may lead us to conjecture, but its motion must have been very awkward on land : its long neck must have impeded its motion through the water, presenting a striking contrast to the organization which so admirably fits the Ichthyosaurus to cut through the waves. May it not, therefore, be concluded, since, in addition to these circumstances, its respiration must have required frequent access of air, that it swam upon or near the surface, arching its long neck like the swan, and occasionally darting it down at the fish which happened to float within its reach? It may, perhaps, have lurked in shoal water along the coast, concealed among the sea-weed, and raising its nostrils to a level with the surface from a considerable depth, may have found a secure retreat from the assaults of its enemies ; while the length and flexibility of its neck may have compensated for the want of strength in its jaws, and its incapacity for swift motion through

[1] Remains of Plesiosauri have since been discovered in the Wealden formation. See "Fossils of Tilgate Forest," Pl. IX.

"the water, by the suddenness and agility of the attack which they enabled it to make on every animal fitted for its prey that came within its extensive sweep." [1]

PLESIOSAURUS HAWKINSII.—*Wall-case D.*—The splendid specimen thus labelled (*Lign.* 73) in the upper compartment of this Case, was one of the earliest examples placed before the scientific world by Mr. Hawkins, as evidence of his consummate skill, and untiring patience and perseverance, in developing the enaliosaurian skeletons from the liassic deposits of England. This fossil, beautifully perfect as it now appears, was reduced to fragments in removing it from the stratum in which it was discovered, and as in the instance of the Maidstone specimen, would have thrown no light on the structure of the original animal, but for the successful result of the labour bestowed on its reparation.[2]

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[1] "Geol. Trans." vol. i. new series, pp. 388, 389.

[2] The following account of the discovery of this specimen is too graphic and characteristic to be omitted. Premising that the specimen named as above by Professor Owen is described by Mr. Hawkins as *Plesiosaurus triatarsostinus*, I give the following extract from the "*Memoirs of Ichthyosauri and Plesiosauri, extinct monsters of the ancient earth*," by Thomas Hawkins, Esq. F.G.S.*

"I was spending the winter of 1831, as usual, in London—the pestilence came just in time to drive me thence to Somerset, for the salvation of the Triatarsostinus. Listen, reader! December gave up the ghost amidst a thousand frightful rumours of the coming cholera: if I remember right, the first of January, 1832, is mournfully distinguished as the day on which one of the morning papers announced 'the scourge' present in Southwark. Who will ever forget the panic that followed? London was comparatively deserted within twenty-four hours. Tuesday six cases were bulletined as having occurred since its breaking out—a distinguished physician assured me that 600 were nearer the truth; along the Borough bank of the Thames, in those crowded houses, what havoc and death!

"Wednesday fatal cases trebled—about twenty were publicly acknowledged—at least a hundred and twenty known to the intelligent few. Ah! I was smoking cigars on the box of the Bath mail all the night, and at ten o'clock, Thursday, galloping over the Mendips—the British Alps—on "the Exeter." The first thing that I ever do when I come to Glastonbury, is to call on my friend—my Pythias—there: the second, to drink a cup of coffee as sedative after my 140 miles journey; the third is to dash over to the lias quarries at a neck-hazard tangent. Now

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* In one vol. royal folio, with numerous beautiful plates, 1834. Copies of this splendid and scarce work may be obtained of Professor Tennant, 149, Strand.

The skeleton is attached to the slab of stone by its dorsal aspect, consequently the under surface of the lower jaw, and the series of cervical vertebræ, is exposed. The pectoral arch, with its large coracoids and anchylosed scapulæ and clavicles, is well preserved; the humerus, radius, and ulna, of each side are in situ, and the right carpus, and some of the phalanges. The sterno-costal arcs of the abdominal region are beautifully shown; and the pubic and ischiac bones of the pelvis are clearly developed; there are no anchylosed sacral vertebræ in the Plesiosaurus. The femora, tibiæ, and fibulæ, and many of the tarsal and digital bones of the paddles, are likewise well defined; and the series of caudal vertebræ, though dislocated from the sacrum, and thrown out of the normal position, is very distinct.

This specimen was figured and described by Dr. Buckland and other authors as Plesiosaurus dolichodeirus; but Professor

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"it happened that a person of Street, by name Creese, a quarrier, a worthy man enow, came across the Triatarsostinus a few days before, and as I had given him no inconsiderable monies for the bones that he had met with in the course of his business, he was at the pains of taking it home in hopes of getting more. The Philistines from Dan to Beersheba know what a vile tendency to mischief every beautiful object that he can set his paw upon disgraces John Bull."

Mr. Hawkins found that in the attempt to clear the specimen, the men had broken it into a hundred pieces, and lost many of the fragments. The narrative thus proceeds:—

"May heaven forgive me—*magna componere parvis*—I have never forgiven the Goths that sacked the Eternal City, the infamous Caliph that destroyed the Alexandrian library—nor these men! When I came to Street so opportunely, they had thrown away nearly the whole of the two anterior paddles, and the whole of the posterior right one—they had reduced the flag-stone to nearly thirty pitiful pieces, and stabbed the bone as a Spanish Matadore does a bull—all over. But I should congratulate myself upon such fortune as fell to my lot, and thank the stars and the cholera that it was no worse, as had I not arrived at that very four of the clock in the afternoon, Bruin had resolved to chissel away the surface of the stone, never dreaming that the process would have swept away the bones too!

"Creese paid a severe penalty for his temerity: instead of giving him as much as my conscience told me was the worth of it—a rule that I have never departed from but in this deserving instance—I was content to pay him liberally for the trouble he had been at in noticing it. The rest of the chapter is short. Some parts of the three minor paddles are recovered. I forgot the pestilence, sat up at work all day and all night, and in about two months the Triatarsostinus, my hewn-god, was finished."

Owen, in his masterly review of the osteology of the Enaliosaurians, has established its specific distinction, and assigned to it the name of its discoverer. There are three other remarkably choice examples of this species in Cases *E* and *F*. That in the latter case is the most exquisite fossil skeleton in the British Museum; the perfection of the bones, the admirable manner in which the stone has been chiselled away, and the graceful position of the neck, head, and limbs, render this precious relic invaluable.

The specific characters which distinguish the Plesiosaurus Hawkinsii from the typical P. dolichodeirus, are chiefly differences in the relative proportion of various parts of the skeleton.

The head is somewhat larger: it is three times the length of the neck, instead of being four times, as in P. dolichodeirus. The length of the neck only slightly exceeds that of the trunk, whereas in the latter it is equal to that of the united body and tail. The number of cervical vertebræ is twenty-nine; in P. dolichodeirus, thirty-five.[1] There are also recognisable differences in the forms and relative sizes of the ulna and tibia.

PLESIOSAURUS ARCUATUS.—*Wall-case D: and on the top of Wall-case E.*—Many detached bones of this species are placed on each side the specimens above described in Case *D*. This species is distinguished by the development of *distinct transverse processes*, from the sides of the centrum of the vertebræ, for the support of the cervical ribs, especially from those of the posterior moiety of the cervical region. "These processes have the articular surfaces traversed by a longitudinal groove, as in other Plesiosauri, and, consequently, thus present the appearance of the two normal transverse processes

[1] *Cervical vertebræ.*—Professor Owen reckons as cervicals those in which the centrum or body of the vertebra bears the whole, or a part of the costal articular surface. "The body of a cervical may always be distinguished from that of a caudal vertebra in being without any trace of hæmapophysial pits. The dorsal vertebræ are those in which the costal surface is situated wholly on the neurapophysis. The caudal vertebræ are characterised by having both costal and neurapophysial impressions on the body, except the terminal ones, which are readily distinguished by their small size, the absence of both the above-named impressions, and by the concave character of their articular surfaces."—"*Brit. Assoc. Reports*," 1839, p. 58.

confluent at the base. The dorsal vertebræ are distinguished by the correspondingly great development of the transverse processes upon the neurapophyses." [1]

Top of the Cases.—Specimens of Plesiosaurus Arcuatus.

Wall-Case E. [5.]			Wall-Case F. [6.]	
Cast of Plesiosaurus macrocephalus: presented by the Earl of Enniskillen.	Plesiosaurus rugosus: from the Lias near Belvoir Castle. The trunk with four paddles.	Two noble specimens of Plesiosaurus Hawkinsii.	Plesiosaurus from Newark; figured in *Phil. Trans.* 1719.	Plesiosaurus dolichodeirus: the trunk and paddles.
				Magnificent specimen of Plesiosaurus Hawkinsii. (Plate 27 of Mr. Hawkins's work. Edit. 1840.)

Plesiosaurus macrocephalus. — *Wall-case E.*—A fine skeleton, between four and five feet in length, from Lyme Regis, discovered and developed by the late Miss Mary Anning, was figured and described by Dr. Buckland under the name of *P. macrocephalus*, from the relatively great size of the cranium as compared with that of the typical P. dolichodeirus.[2] A cast of this specimen was presented to the British Museum, by that eminent and zealous palæontologist, the Earl of Enniskillen; and the osteology of this species is fully elucidated by Professor Owen.[3]

The arched position into which the vertebral column has been thrown, presents the entire skeleton on a comparatively small area. The upper part of the cranium, with the orbits, and the jaws and teeth, are exposed. The cervical and dorsal vertebræ form a continuous, and but slightly dislocated series: the tail is imperfect; the anterior and posterior paddles of the left side are entire.

The length of the neck exceeds that of the lower jaw only twice, instead of thrice as in P. Hawkinsii. The greater development of the head is associated with thicker and stronger vertebræ; there are twenty-nine in the cervical region; the

[1] "Brit. Assoc. Rep." p. 75.
[2] Dr. Buckland's "Bridgewater Essay," Pl. XIX.
[3] "Brit. Assoc. Reports," 1839, pp. 62—69.

vertebræ are shorter than in the species previously described, and approach in their proportions to those of the Ichthyosaurus: the processes of the cervical vertebræ are stronger.

The dorsal vertebræ differ from those of P. Hawkinsii in the bodies being more flattened antero-posteriorly, and more concave laterally. Other osteological characters, establishing the specific distinction of this Plesiosaurus, are minutely detailed in the Reports so often cited.

PLESIOSAURUS RUGOSUS.—*Wall-case D.*—This specimen of a very rare species of Plesiosaurus was discovered in the Lias near Belvoir Castle, and presented to the British Museum by the Duke of Rutland. It consists of the cervical region of the vertebral column, a considerable portion of the bones of the trunk, those of the four paddles, and some of the vertebræ of the tail; but the latter are much displaced. The cranium is wanting.

Some detached Plesiosaurian vertebræ, readily distinguished from all others by the peculiarly rugous character of the free, or non-articular surfaces of the body, were ascribed to a distinct species, under the name of *P. rugosus*, in "Brit. Rep." 1839; and other characters of these isolated bones were pointed out.[1] The discovery of the skeleton before us has confirmed the accuracy of the distinction.

Among other peculiarities, Prof. Owen remarks, that the two costal impressions on each side the bodies of the middle cervical vertebræ are in this species completely divided, and by a wider and deeper groove; and they are situated near the lower margin of the vertebra. The contour of the articular surface of the vertebral body is almost circular, the peripheral border being convex, and leading inward to a concavity, and the centre of this surface is slightly convex.

The absence of the cranium, and the dislocated state of the spinal column, together with the loss of many of the vertebræ, render it useless to give a more particular description.

PLESIOSAURIAN REMAINS FROM THE WEALDEN.—Among the reptilian bones discovered in the strata of Tilgate Forest, were dorsal and cervical vertebræ of Plesiosauri, referable to one of the typical species previously described: probably the P. dolichodeirus: some of them are figured in my "Fossils of Til-

[1] "Brit. Assoc. Rep." 1839, p. 82.

gate Forest."[1] Several teeth, and specimens of the median bones of the sterno-costal arcs, and portions of coracoids of plesiosauri, have also been found in other localities. These remains were in the same fragmentary and waterworn condition as those of the terrestrial reptiles.

The occurrence of the bones of this remarkable type of marine saurians in the freshwater formation of the south-east of England, may be attributable to the influx of the tidal waters into the ancient estuaries and bays; but it is also probable, from the presumed habits of the Plesiosauri, that the embouchure of the river of the Country of the Iguanodon was frequented by shoals of these reptiles, as well as by turtles and predatory fishes. Unfortunately, the bones of Plesiosauri collected by me, and transferred to the British Museum in 1839, are not yet placed so that they can be referred to in this volume; but the fact is worthy of record in relation to the history of the Wealden formation.

*** In consequence of the arrangement of the fossils in this room, we must defer the consideration of the other group of Enaliosaurians, the Ichthyosauri, till the next chapter, and proceed to notice the contents of Wall-case *G*, which chiefly consist of an interesting series of mammalian and other remains, from the tertiary deposits of Central France. (See *ante*, p. 143.)

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[1] 1 Vol. 4to. Published in 1827, Pl. IX. figs. 4, 5; Pl. XVII. fig. 20, p. 79.

CHAPTER III.

PART VIII.

FOSSIL REMAINS OF MAMMALIA.

GEOLOGICAL PHENOMENA OF AUVERGNE—EOCENE AND MIOCENE MAMMALIA —DISCOVERIES OF M. POMEL—COLLECTION OF MAMMALIAN REMAINS FROM AUVERGNE IN THE BRITISH MUSEUM—FOSSIL BEAVER; TROGONTHERIUM —TAILS OF GLYPTODONS.

GEOLOGICAL PHENOMENA OF AUVERGNE.—*Wall-case G.*—The fossils in this cabinet are chiefly remains of extinct mammalia from tertiary lacustrine marls and limestones, and were collected by M. Pomel, an eminent French naturalist, from a province in Central France, named the *Limagne d'Auvergne;* a district of surpassing interest in a geological point of view, for it presents the remarkable phenomenon of an extensive tract of country which has been subjected through long periods to successive volcanic eruptions, and yet the area of those physical revolutions, though studded with extinct craters, and traversed by lava currents, still preserves its ancient geographical features.

The specimens are at present unarranged; and many of the bones, teeth, crania, and jaws, are not entirely cleared from the rock; but the eminent zoologist, MR. WATERHOUSE, of the palæontological department of the British Museum, has already with great skill and patience brought to light many unexpected treasures in the collection purchased of M. Pomel by the Trustees, and is diligently engaged in

developing and determining the zoological characters and relations of this highly interesting series of mammalian remains.

The country whence these fossils were obtained, and which is the site of the extinct volcanoes, is about 220 miles south of Paris, and forms a vast plain, situated in the department of the Limagne d'Auvergne. It is so remarkable for its fertility, that it is called the Garden of France; a quality attributable to the detritus of volcanic rocks which enters into the composition of the soil. It is enclosed on the east and west by two parallel ranges of gneiss and granite. Its average breadth is twenty miles, its length between forty and fifty, and its altitude about 1,200 feet above the level of the sea. The immediate subsoil of this plain is formed of alluvial deposits composed of granitic and basaltic pebbles and boulders, spread over beds of freshwater limestone.

Hills of various elevations are scattered over the plain; and the river Allier flows through the district over strata of limestone, marl, and sandstone, except where it has excavated a channel through these sedimentary beds to the foundation rock of granite. The calcareous deposits are the remains of a formation which once constituted an ancient plain of a higher elevation than the present tract; many of these hills are capped by a crest of basalt, to which their preservation is in great measure owing; others have escaped destruction in consequence of the durable and hard nature of the limestone of which they are composed.

Thus we have as the ground plan of the district, an extensive plain, checquered with low hills of fresh-water limestone, that are capped with compact lava;[1] the boundaries of this tract being a range of primary rocks, 3,000 feet high. To the westward the limestone disappears, and a plateau of granite rises to a height of 1,600 feet above the valley of Clermont, being 3,000 feet above the level of the sea. This elevated tract supports a chain of volcanic cones and dome-shaped mountains,[2] about seventy in number, which vary in altitude from 100 to 500 feet above their bases, and form an irregular range of

[1] I would refer the reader to "Wonders of Geology," p. 268, for a more particular account of these phenomena; the classical works on the geology of Auvergne are therein pointed out.

[2] Ibid. Pl. II.

nearly twenty miles in length, and two in breadth. The highest point of this chain is the Puy de Dome, which is 4,000 feet above the level of the sea, and is entirely composed of volcanic matter; it has a regular crater which is 300 feet deep, and nearly 1,000 feet in circumference.

The volcanic vents of Central France are of very different ages; some being of immense antiquity, whilst others are evidently of comparatively recent origin, for they have exploded through ancient beds of basalt: but even the most modern of the craters and lava streams, belong to a period very remote in relation to the present condition of the country.

In the plains, and on the flanks of the volcanic mountains, and rising into hills of moderate elevation, are a series of fresh-water strata, with alternations of scoriæ, basalt, &c. based on the foundation rocks of granite and gneiss. The lowermost beds are for the most part composed of clay, sand, and breccia, without organic remains. The next in order are fresh-water tertiary limestones and calcareous marls, in nearly horizontal strata, amounting in total thickness to 900 feet. It is in these beds that the mammalian remains we have to notice occur: they are associated with lacustrine and fluviatile shells, as potamides, planorbis, helix, limnea, &c. and terrestrial plants. In some localities there are beds of gypseous and laminated marls, and intercalations of siliceous limestones; in other areas, the limestone has an intermixture of volcanic matter, and presents the characters of a sediment tranquilly deposited in a lake, into which ashes and scoriæ were showered from a neighbouring volcano.

The fresh-water limestones are in many places covered by thick beds of basalt and scoriæ, and the summits of the lower hills composed of these strata are capped by basaltic lava. The Drift, or alluvial sand and gravel, contains bones of mastodons, elephants, hippopotami, &c. as in other countries of Europe; and the more modern superficial soil abounds in remains of dogs, hares, beavers, bears, &c.

Eocene and Miocene Mammalia.—The mammalian remains from this region have been referred to three very distinct geological epochs;[1] *viz.*:—

[1] See Sir Charles Lyell,—"Proceedings of the Geol. Society," 1845, p. 75.

I. Mammalia of the most ancient fresh-water strata; from the presence of remains of palæotheria, anoplotheria, and other Cuvierian pachyderms, these deposits are regarded as Eocene and Miocene tertiary.

II. Mastodon, Hippopotamus, Elephant, Horse, Tapir, &c. all supposed to be extinct species; the beds in which these occur are separated from the previous group by ancient lavas.

III. Bones from the sandy marl and alluvial debris. These are referable to small Rodents (*Lagomys*), and nearly 50 species of other existing mammalia; as Squirrel, Hare, Martin, Dog, Cat, &c. Hog, Ox, Deer, Horse; and Reptiles, as Frogs, Lizards, Snakes; several kinds of Birds; and *eggs* of reptiles and birds.[1]

Discoveries of M. Pomel.—Sir Charles Lyell, in the recent edition of his "Elements of Geology," remarks, that it cannot with certainty be determined whether all the fresh-water strata of the Limagne d'Auvergne belong to one period, because extensive beds both of the arenaceous and marly groups are often devoid of fossils. "Much light has been thrown on the mammalian fauna by the labours of MM. Bravard and Croizet, and by those of M. Pomel. The last-mentioned naturalist has pointed out the specific distinction of all, or nearly all, the mammalia, from those of the tertiary gypseous series near Paris. Nevertheless, many of the forms are analogous to those of eocene quadrupeds. The *Cainotherium*, for example, is not far removed from *Anoplotherium*, and is, according to Mr. Waterhouse, the same as the genus *Microtherium* of the German naturalists. There are two species of marsupial animals allied to *Didelphys*, a genus also found in the Paris gypsum. The *Amphitragulus elegans* of Pomel, has been identified with a Rhenish species from Weissenau near Mayence, called by M. Kaup *Dorcatherium nanum;* and other Auvergne fossils, *e. g. Microtherium Reuggeri*, and a small rodent, *Titanomys*, are specifically the same with mammalia of the Mayence basin."[2]

Collection in *Wall-case G.*—The collection formed by M. Pomel, which is now before us, is chiefly, as I am informed

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[1] "Wonders of Geology," p. 274.

[2] "Manual of Elementary Geology," 1851, p. 188. See also p. 425, of the same volume.

by Mr. Waterhouse, from the eocene marls and limestones, near Clermont; fresh-water shells are associated with the bones, and no traces of marine remains of any kind have been discovered.

The bones and teeth, though friable, are in a beautiful state of preservation; and Mr. Waterhouse has most successfully developed some exquisite crania and jaws of an extraordinary little extinct Pachyderm (not larger than a rabbit) which inhabited ancient Auvergne.

There are bones and teeth of many genera of Anoplotheridæ.

Anthracotherium, several species.

Cainotherium : a sub-family of Anoplotheridæ.

A small and very peculiar Ruminant.

An animal approaching the Musk-deer (*Amphitragalus* of M. Pomel).

Hyænodon (found, also, at Hordwell, in Hants).[1]

Many small Rodents of species and genera discovered by Searles Wood, Esq., in the eocene deposits, at Hordwell, in Hants.[2]

Small carnivora, allied to the Weasels. (*Mustelidæ.*)

Jaws of small marsupials. (*Didelphidæ.*)

Fresh-water Turtles. (*Emydians.*)

Crocodilian and batrachian reptiles.

Small lacertian reptiles.

Birds : several species and genera.

Eggs of birds, and probably, also of reptiles.

For the above list of this highly interesting series of mammalian remains from the tertiary lacustrine deposits of the volcanic regions of France, I am indebted to the kindness of Mr. Waterhouse; when this collection is thoroughly arranged, and the characters of the species and genera are determined, it is to be hoped this accomplished naturalist will lay before the public a full account of these palæontological treasures.

Trogontherium Cuvieri. — *Wall-case G.*—The rivers of England and of the Continent were inhabited by Beavers at no very remote period, and in more ancient times extinct species or sub-genera of this family, of a large size, were denizens of modern Europe. In the lowermost compartment of

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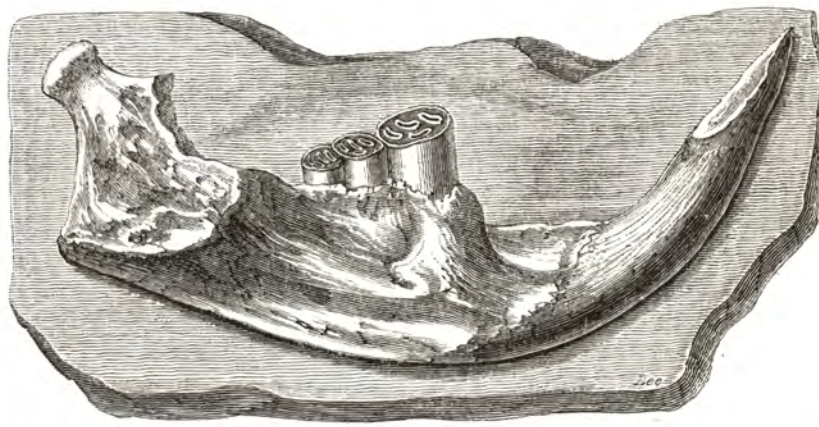
[1] See my "Geology of the Isle of Wight," p. 438.

[2] Figured and described in "London Palæontological Journal," Pl. II.

this case there is a very interesting fossil relic of this kind—the half of the lower jaw of a gigantic animal allied to the existing genus Castor, which was discovered by the Rev. J. Green, in a lacustrine deposit of clay and sand at Ostend, near Bacton, on the coast of Norfolk; a locality which has yielded remains of mammoths, deer, roe-bucks, large water-moles, &c.[1]

The incisor (which is longer and stronger than in the existing Beavers), the molar teeth, and the articulation of the jaw, are beautifully displayed in this highly interesting British example of a gigantic extinct rodent, whose relics were first discovered in Russia, a cranium having been found by M. Fischer, on the borders of the Sea of Azof, in 1822.[2] The original was probably about one fifth longer than the common species of Beaver. The skull and jaws of a much larger rodent related to the Castor, has lately been discovered in the



LIGN. 74.—LOWER JAW OF AN EXTINCT GIGANTIC BEAVER, FROM OSTEND, NORFOLK. ($\frac{1}{2}$ *nat. size.*)

alluvial deposits that contain the remains of Mastodons, in the State of Ohio. An admirable memoir on this cranium has been published by the eminent American palæontologist, Dr. Jeffries Wyman. The name of *Castoroides Ohioensis* has been given to this colossal beaver; the entire length of the original

[1] See Professor Owen's elegant and interesting "History of British Fossil Mammals," p. 25.

[2] Described by Baron Cuvier, under the name of *Castor Trogontherium*, "Oss. Foss." Vol. v. Part I. p. 59.

animal is estimated at twice that of the existing species, viz. five feet.[1]

GLYPTODON.—*Wall-case G.*—In the lowermost compartment of this case, there are two remarkable relics of colossal edentate animals allied to the Armadillos, to which I would direct the visitor's attention; but it will be convenient to reserve an account of the geological conditions in which these and similar remains occur, till the skeletons of gigantic animals of this order in Room VI. come under examination.

I will, therefore, only remark that these fossils are the osseous dermal cases, or sheaths, of the tails of two distinct species of Glyptodon; an animal somewhat resembling the Armadillo, being covered with a coat of mail, formed of polygonal osseous plates, united by sutures, that constituted an impenetrable covering to the body. The plates of this bony investment were not disposed in rings, as in the Armadillos, but were articulated to each other, and formed a tesselated cuirass; the tail was inclosed in a case of this kind, like a sword in its scabbard.[2]

LIGN. 75.—THE OSSEOUS DERMAL CASE OF THE TAIL OF A SPECIES OF GLYPTODON ($\frac{1}{18}$ *nat. size.*)

One of the specimens in the British Museum appears to belong to the species named *Glyptodon clavipes;* but the other (see *Lign.* 75), which is nearly three feet in length, is remarkable for the expanded lobes near the distal termination of the tail. These fossils are deserving of particular examination; they will, I presume, sooner or later, be placed in Room VI. with the other remains of the Edentata of South America.[3]

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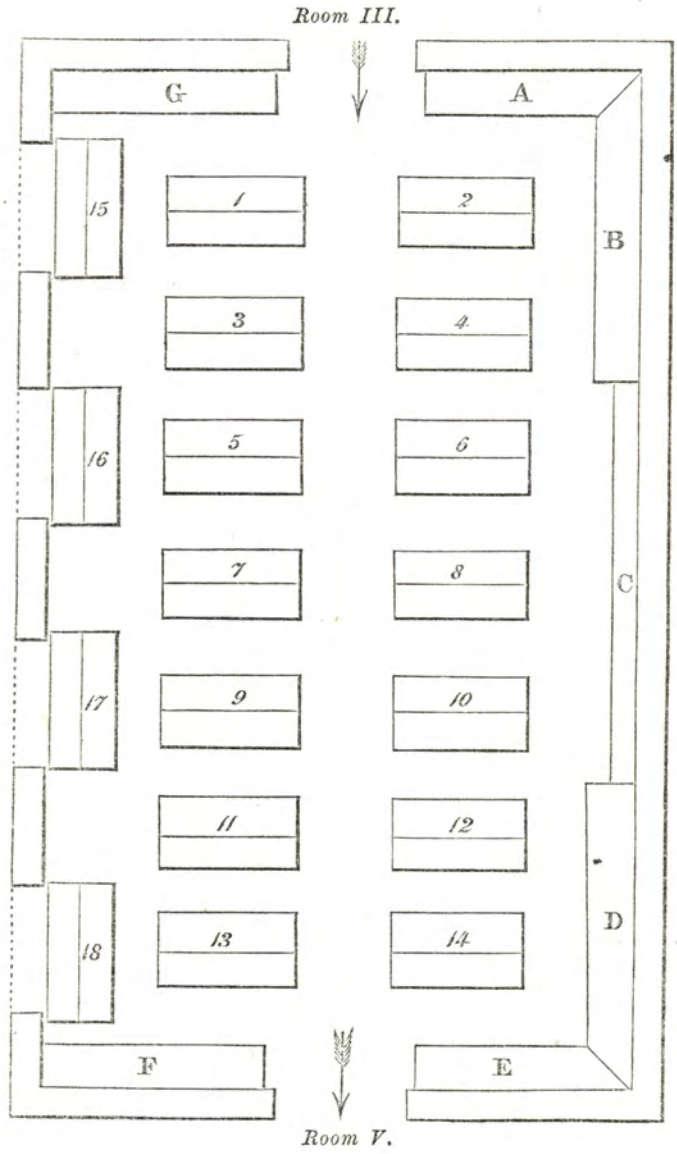
[1] "Boston Journal of Nat. Hist." 1846.

[2] A splendid specimen of the bony cuirass of the Glyptodon is in the Hunterian Museum of the Royal College of Surgeons, in London.

[3] A restored figure of the Glyptodon forms the frontispiece of the highly interesting work on "Buenos Ayres and the Province of Rio de la Plata," by Sir Woodbine Parish, K.C.H. &c.; the indefatigable explorer, to whom science is indebted for the most important examples of the extinct colossal Edentata hitherto brought to Europe.

PLAN OF ROOM IV.



CHAPTER IV.

PART I.

PLAN OF ROOM IV.—SYNOPSIS OF CONTENTS—ICHTHYOSAURI COLLECTED BY MR. HAWKINS—ICHTHYOSAURUS TENUIROSTRIS—I. INTERMEDIUS—I. LONGIPENNIS—I. COMMUNIS—I. PLATYODON—I. LONCHIODON—I. LONGIROSTRIS—FOSSIL REMAINS OF RUMINANTS—FOSSIL CARNIVORA OF THE CAVERNS—MACHAIRODUS—FOSSIL MAMMALIAN FROM STONESFIELD—MINERALS—UNIVALVE SHELLS OF THE OOLITE AND CRAG—FOSSIL ZOOPHYTES.

THE Wall-cases *A*, *B*, *C*, *D*, *E*, on the south or left side of Room IV., like those in the apartment we have just surveyed, are assigned to fossil remains of reptiles, and contain a noble collection of ICHTHYOSAURI, from the liassic deposits of England. With but few exceptions, these splendid specimens were obtained and developed by Thomas Hawkins, Esq. of whom they were purchased by the Trustees of the British Museum, together with the unrivalled series of Plesiosauri described in the former chapter.

A collection of bones of ruminants from the alluvial deposits of the valley of the Thames, chiefly from Grays and Ilford in Essex, is deposited in Wall-case *F*. It comprises some fine skulls, jaws with teeth, and bones of the extremities, of several species of Bos or Ox, Deer, &c.

In Wall-case *G*, there is a considerable number of very perfect crania, jaws with teeth, &c. of extinct species of Bears, from the ossiferous caves of Gailenreuth, in Germany; and a most interesting and precious fossil relic—the half of the lower jaw of a small terrestrial mammalian, from the lower Oolite of Stonesfield.

Besides the fossils above specified, there are many species and genera of tertiary and secondary univalve shells, and

corals and other zoophytes, which occupy three Table-cases. The other cabinets contain minerals only.

These numerous and diversified objects will be noticed under the following sections; viz.—I. Synopsis of Contents. II. The Ichthyosauri. III. Fossil remains of Ruminants. IV. Fossil Carnivora of the Caverns. V. The Fossil Mammalian of Stonesfield; and VI. the collections of Shells and Zoophytes: of the last, a brief notice only is within the scope of the present volume.

ROOM IV.

(62 *feet long.*)

Synopsis of Contents.

ORGANIC REMAINS.

Wall-cases: these contain a fine suite of Ichthyosauri, from the Lias formation of England.

A. [1.] Specimens of

Ichthyosaurus tenuirostris.
——————— *intermedius.*
——————— *longipennis.*
——————— *communis.*

In one specimen coprolites are seen in the abdominal space.

Ichthyosaurus platyodon.—There is a very large and fine skull and jaws of this species, with the osseous plates of the sclerotica perfect, and part of the spinal column.

B. [2.] Two specimens of *Ichthyosaurus intermedius.*

On a slab of Lias limestone there is a fine Ichthyosaurus, with the spine in an arched position, and the four paddles nearly entire; from Street, Somersetshire.

There are in this compartment many small examples of paddles, and other detached parts of Ichthyosauri.

C. [3.] In this Case is a noble skeleton of *Ichthyosaurus platyodon,* eighteen feet long; and a small and beautiful Ichthyosaurus, presented by Mr. Broderip.

D. [4.] In the upper division is a splendid specimen of *Ichthyosaurus communis.*

The lower compartment contains a large example of *Ichthyosaurus lonchiodon;* the paddles imperfect. In the angle on the right, is deposited a small and beautiful head of *Ichthyosaurus tenuirostris:* and below, a specimen of *Ichthyosaurus latifrons.*

E. [5.] An interesting example of *Ichthyosaurus tenuirostris* is placed in the upper division. In the lower, there is an exquisite *Ichthyosaurus intermedius,* showing the upper surface of the skull, the spinal column, and paddles; and a specimen of *Ichthyosaurus longirostris.*

F. This Case contains numerous bones of Ruminants, among which is a skull of *Bos longifrons;* bones and antlers of Deer, &c.

On the top of this Case is placed the skull and horn-cores of a species of Bos, from Texas.

G. This Case, which is at the east end of the room, to the right of the doorway on entering, contains many skulls and bones of Bears, Hyænas, and other carnivora, from the caves of Gailenreuth, &c.

On the upper shelf there is a cast of the skull and jaws of the *Machairodus,* (*Ursus cultridens* of Cuvier); a remarkable extinct carnivorous animal whose upper canines are very long and of a sabre-like form, resembling the teeth of the Megalosaurus.

In this Case, in a small glass frame, there is one of the most valuable fossils in the collection: the *lower jaw of a small marsupial animal* on a slab of Oolitic limestone, from Stonesfield, in Oxfordshire. It is labelled *Didelphis Bucklandi;* presented by W. J. Broderip, Esq. F.R.S. It is represented in the vignette of the title page of this volume.

MINERALS.

TABLE-CASE 1.—[37.] One half of this table is set apart for silicates containing glucina and alumina, the principal species of which is the Beryl, including the Emerald, a gem which owes its green colour to oxide of chromium. The other part of the table is occupied by oxides of Titanium and titanites.

2. [24.] One half of the Case contains varieties of Jasper. The other half is appropriated to Opaline substances,—the noble opal; sun-opal; common opal; semi-opal; wood-opal, or opalized wood; menilite; quincite.

3. [36.] Varieties and species of Garnet,—chrome-garnets; lime-garnets; colophonite, &c.

4. [25.] Silicates of lime, and some of the silicates of magnesia and of alumina. Wollastonite; Steatite or soapstone; keffekil or meerschaum, of which pipe-bowls are made; Serpentine; Hydrophite; metalloid diallage or diallagite; Chrysolite or periodot.

5. [35.] Pyroxenic minerals. Augite imbedded in lava from Vesuvius; thallite; sahlite; epidote. Idocrase from Vesuvius, &c.

6. [26.] Silicate of Zinc, or Smithsonite. Silicate of magnesia—of cerium—of iron—of copper—of bismuth—of zirconia — of alumina. Andalusite. Kyanite or disthène. Sillimanite. Xanthite. Catlinite or Indian pipe-stone. Agalmatolite, employed by the Chinese for images, vessels, &c.

7. [34.] Abestine and Pyroxenic minerals. Asbestus; amianthus; augite; jeffersonite; yenite from Elba; sahlite.

8. [27.] Zeolitic substances. Apophyllite; chabasite; mesotype; natrolite, &c.

9. [33.] Amphibolic and pyroxenic minerals. Basaltic and common hornblende; actinolite; tremolite, &c.

10. [28.] Zeolitic substances. Stilbite; Heulamdite; Laumontite; Comptonite from Vesuvius; Thompsonite; hydrolite, &c.; and several other scarce zeolitic minerals.

11. [32.] Micaceous and talcose substances.

12. [29.] Prehnite. Koupholite. Jade or nephrite, of which there are some manufactured articles. Harmotome; Andreolite, a magnificent specimen. Herschelite. Felspar, &c.

13. [31.] Felspathic substances. Triphane; spodumen; petalite; Davyne; nepheline; Wernerite.

14. [30.] Felspathic substances. Common felspar; amazonstone from the Urals; icespar; albite; adularia, &c.; Labrador felspar; leucite or amphigène from Vesuvius.

*** With these Cases the collection of minerals terminates, the Table-cases in Rooms V. and VI. being devoted to fossil remains.

It may be useful to the student to know that in the cabinets we have enumerated, the same mineral species in each Case is indicated by a coloured border corresponding with that of the label on which the name of the mineral is written; as, for example, the same coloured margin as that on the ticket "QUARTZ," surrounds every specimen of *quartz* in that Case.[1]

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15. Fossil shells of Gasteropodous mollusks, (*holostomata* and *siphonostomata,*) from Tertiary and Secondary strata, named and arranged by Mr. Woodward. There are many very fine specimens from the *Great Oolite* of Minchinhampton.

A polished slab of a septarium showing displaced sections of shells, (*Turritella imbricata,*) from the London clay of Western Sussex, (discovered by the Author,) is very interesting; a mass of perfect shells of the same species is placed near it.

16. *Vacant.*

17. This Table-case contains a collection of fossil Zoophytes, as *Corals, Sponges,* &c. Many are from the Bradford clay; others from the Silurian limestone of Dudley, Wenlock, &c.

There is likewise a series of the larger forms of *Foraminifera;* viz. *Nummulites, Orbitolites,* &c.

18. Fossil univalve shells from tertiary strata; chiefly from the Eocene deposits of Grignon, near Paris; Hordwell, &c.; and from the *Coralline, Norwich,* and *Red Crag.*

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[1] Communicated to me by Prof. Tennant.

CHAPTER IV.

Part II.

THE ICHTHYOSAURI.

DISCOVERY OF THE ICHTHYOSAURUS — MR. KÖNIG AND SIR E. HOME — MISS MARY ANNING — REV. W. D. CONYBEARE AND SIR H. DE LA BECHE — REV. DR. BUCKLAND — MR. HAWKINS — THE LIAS FORMATION — STATE OF PRESERVATION AND STRUCTURE OF THE ICHTHYOSAURUS — PADDLES — INTEGUMENTS, &c. — COPROLITES — SPECIES OF ICHTHYOSAURUS IN THE BRITISH MUSEUM — ICH. TENUIROSTRIS — ICH. INTERMEDIUS — ICH. LONGIPENNIS — ICH. COMMUNIS — ICH. PLATYODON — ICH. LONCHIODON — ICH. LONGIROSTRIS — ICH. LATIFRONS — RETROSPECTIVE SUMMARY.

Discovery of the Ichthyosaurus.—Nearly forty years have elapsed since the attention of the scientific world was first directed to the fossil remains of this extraordinary tribe of marine reptiles by a memoir, by the late Sir Everard Home, on a cranium, and other parts of the skeleton, that were exhibited in the then celebrated museum of Mr. Bullock, in Piccadilly. Teeth, vertebræ, and other detached parts of the skeleton of these animals, had attracted the notice of the earlier collectors of British fossils; but until Sir Everard Home's communication to the Royal Society, in 1814, no definite idea as to the nature of the originals had been entertained. The anomalous character of these fossil skeletons, which in certain parts of their structure resembled those of fishes, and in others those of crocodiles, suggested the name, so happily chosen by my friend Mr. König, the accomplished "Keeper of Mineralogy and Geology of the British Museum," of *Ichthyosaurus*,[1] or fish-like lizard; a name by which this group

[1] Ἰχθὺς, a fish, and Σαῦρος, lizard.

of marine reptiles is now distinguished. Many instructive specimens were soon discovered, and important additions rapidly made to the knowledge of these extinct denizens of the ancient ocean, by Dr. Buckland, Sir H. De la Beche, Mr. Conybeare, &c. But the name of an humble individual, to whose talent and perseverance in discovering and developing these relics of former ages, the eminent naturalists above mentioned were mainly indebted for the objects of their investigation, must not be omitted even in this brief sketch of the history of the Ichthyosaurian remains in the British Museum; that person was the late *Mary Anning*, of Lyme Regis, who, —to employ Mr. Hawkins's graphic language,—"devoted herself to science, and explored the frowning and precipitous cliffs, when the furious spring-tide conspired with the howling tempest to overthrow them, and rescued from the devouring ocean, sometimes at the peril of her life, the few specimens which originated all the facts and ingenious theories of those eminent persons, whose names must ever be remembered with sentiments of the liveliest gratitude." [1]

Several memoirs were published by Sir E. Home and others on detached parts of the skeleton, and in 1821, Messrs. Conybeare and De la Beche communicated to the Geological Society a "Memoir on the genus Ichthyosaurus," in which the osteology of the original was so fully elucidated, as to leave but few points undetermined, for the investigation of subsequent observers.

Ten years afterwards, Mr. Hawkins astonished British naturalists by the splendid and perfect skeletons of several new species of both tribes of Enaliosauri, which his anatomical skill, and untiring perseverance and patience, enabled him to dissect from the rock, in a state of integrity previously thought unattainable. The principal gems of that gentleman's collection are now before us, having been purchased by the Trustees of the British Museum.[2]

To the admirable Memoir on the Enaliosauransi, by Baron Cuvier, in 1823,—the beautiful illustrations in the Bridgewater

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[1] "Memoirs of Ichthyosauri," &c. by Thomas Hawkins, Esq. 1 vol. folio, 1834, p. 9.

[2] Two collections were purchased of Mr. Hawkins; the first was valued by Dr. Buckland and myself. See APPENDIX K.

Essay, by Dr. Buckland,—and the elaborate and highly philosophical review of the subject, and the determination of all the then known species, by Professor Owen, in 1839, in the "Reports on British Fossil Reptiles," undertaken and published under the auspices of the British Association of Science, —we are indebted for the present advanced state of this department of British Palæontology. The number of species of both genera is now considerable, and many specimens, both of Ichthyosauri and Plesiosauri, have been discovered in various localities on the Continent.

THE LIAS FORMATION.—Although remains of Enaliosaurians occur in all the formations from the *Muschelkalk* below the Lias, to the Chalk inclusive, it is in the liassic deposits that the greatest number, and the most perfect examples, have been discovered; and as the specimens which now engage our attention were collected from those strata by Mr. Hawkins, I shall offer a few remarks on the geological characters of the localities whence these splendid fossils were obtained.

The *Lias*, situated between the Triassic, or New Red Formation, and the Oolite, consists of a series of argillaceous limestones, marls, and clays, which may be regarded as forming the base of the latter formation, for there are scarcely sufficient grounds for their separation; the *Upper Lias*, and the *Inferor Oolite* which lies upon it, having many fossils in common, and in some localities passing into each other. The total thickness of the Lias varies from 500 to 1000 feet: the strata have a very uniform lithological character, and contain many peculiar organic remains.[1]

The Lias appears beneath the Oolite, through the south-east of Somersetshire, and extends into Dorsetshire, forming a range of cliffs, above four miles in length, along the sea-shore at Lyme Regis, where it may be traced on the coast till it gradually sinks beneath the Inferior Oolite. Lyme Regis in Dorsetshire, and Watchet, Street, and Westbury, in Somersetshire, are the localities that have afforded the most instructive specimens.

The subdivisions of the Lias are characterised by the abundance of particular groups of fossils. Some of the strata

[1] See "Wonders of Geology," p. 521; and Sir C. Lyell's "Elements of Geology," p. 273.

contain a greater number, and more perfect skeletons of saurians, than others. The uppermost beds consist of *Alum shale*, with a profusion of ammonites and crinoidal remains. The next subdivision comprises strata of marlstone and blue marl, in which bones of Enaliosaurians are but rarely met with; but ammonites, belemnites, and other cephalopoda, and the usual marine shells and zoophytes of the Liassic formation are abundant.

The next group, the limestones, is the grand depositary of the reptilian remains,—"the inestimable treasury of the most splendid epoch in the physical records of our planet."[1] Some of the thin intermediate layers of stone are, however, literally a mass of pentacrinites, and others are wholly made up of ammonites; the organic remains being more or less mineralized by pyrites.[2]

The most beautiful and perfect examples of Plesiosauri and Ichthyosauri collected by Mr. Hawkins, were extracted from these strata. The total thickness of the limestones, and alternating layers of marl, at Kingston, near Street, is about twenty feet; at Lyme Regis (forty miles from Street), the section east of Church Cliff, is thirty feet thick.

A bituminous marl, of a black colour, the last deposit in the series, contains similar remains with the limestones; and in addition, some fossil terrestrial vegetables not observed in the other strata.[3]

At the base of the Lias, and separating the lowermost shale from the uppermost Triassic bed beneath, there is a layer of coarse detritus, a few inches thick, commonly known as the *Bone-bed*, composed of mud and sand, and the debris of fishes and reptiles.[4]

STATE OF PRESERVATION OF ENALIOSAURIANS.—The remarkably perfect state of the skeletons of the Plesiosauri has already been pointed out; many of those of the Ichthyosauri are equally entire. In several of the specimens in the Museum, the bones are seen in all their integrity, as in recent anatomi-

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[1] Mr. Hawkins's Memoir, p. 5.

[2] Specimen of *Pentacriniles* from these strata are deposited in Wall-case *G*, Room II. see *ante*, p. 74.

[3] Mr. Hawkins's Memoir, p. 7.

[4] See "Wonders of Geology," p. 529.

cal preparations. Reflecting on the circumstance that the Enaliosaurians lived in an ocean which swarmed with predaceous fishes and other animals, and that both genera were carnivorous, and doubtless preyed on the young and the feeble of their own races, it seems difficult to account for the great number of entire carcasses that must have been buried in the mud at the bottom of the sea, and left unmolested on the spot where they died and became imbedded.

In explanation of this fact, Dr. Buckland has suggested the probability that these creatures experienced a sudden death, from a diffusion of mephitic vapours through the water, by a submarine volcanic eruption; such a phenomenon, it is inferred, would account for the destruction of shoals of those reptiles that were within the reach of the gaseous influence, and at the same time prevent the approach of any predaceous animals, till the carcasses were enveloped in the mud, and placed beyond the reach of assailants.

In connexion with the facts referred to, it is worthy of remark that the Ichthyosauri are, for the most part, found lying on the side, while the Plesiosauri are extended on their backs, with the abdominal region uppermost, as in the splendid fossil figured in *Lign.* 73. It has been very ingeniously conjectured by Mr. Samuel Stuchbury,[1] that this difference of position is referable to the form and structure of the animals of the two genera. In the case of the Plesiosauri it is assumed, that after death, the gases evolved by putrefaction from the abdominal viscera, were retained by the tough dermal integuments and the sterno-costal arcs, and the body was thus suspended with the belly uppermost, till it became water-logged, and buried in the silt. Whereas the fish-like form of the Ichthyosauri,—the vertical diameter of the body being greater than the lateral,—is presumed to account for the lateral position of the fossil skeletons; while the frequently dislocated state of the bones is supposed to have resulted from the strong integuments of the body having remained entire, until the internal parts were decom-

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[1] "Description of a new species of Plesiosaurus (*P. megacephalus*), in the Museum of the Bristol Institution." By Samuel Stuchbury, Esq. F.G.S. "Geolog. Journal," vol. ii. 1846, p. 411.

posed and the bones disunited, but kept from dispersion, as in a sack, till the whole mass was imbedded.

STRUCTURE OF THE ICHTHYOSAURUS.—The Ichthyosaurus, though agreeing in its general characters with the Plesiosaurus, presents a much nearer approach to the fishes than that genus of Enaliosaurians. From the shortness of the neck, and great breadth of the base of the cranium, its general outline must have closely resembled that of a large Porpoise, or Grampus, with enormous eyes, two pairs of fins or paddles, a long tail, and, probably, a large integumentary caudal fin.

The internal structure corresponds with the outer form in its close approximation to fishes or cretaceans. The vertebræ have their articular surfaces so deeply cupped, that it is inferred "they were originally connected together by an elastic capsule, filled with a fluid, as in the vertebral joints of fishes, and the perennibranchiate, or most fish-like, of Reptiles."[1]

The muzzle of the Ichthyosaurus is long and pointed; the lower jaw is formed of two branches, united anteriorly through nearly half their length; each branch is composed of six bones, as in the Crocodiles and Lizards, but differently arranged than in those reptiles.

The teeth are very numerous, amounting to nearly two hundred in some species, and are placed in a single row on each side the jaws, being implanted in a deep continuous groove without sockets. These teeth are of a pointed conical form, longitudinally striated, with an expanded base. The new teeth are developed at the inner side of the base of the old ones, and grow up and displace them. The tooth consists of a pulp-cavity, surrounded by a body of dentine, which is invested at the base by a thick layer of cement, and at the crown by a coat of enamel; the pulp-cavity, in fully-formed teeth, is more or less occupied by coarse bone.[2] The chief peculiarity of this structure consists in the inflection of the cement into vertical folds at the base of the tooth, by which the marginal portion of the basal dentine is divided into a corresponding number of processes, as in the

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[1] Professor Owen, on the Ichthyosaurus. "Brit. Assoc. Rep." 1839, p. 87.

[2] See Prof. Owen's "Odontography," p. 275.

tooth of the Lepidosteus, an existing genus of river fishes. (See "Medals of Creation," Pl. VI. fig. 9.).

The nasal apertures, or openings of the nostrils, are placed as in the Plesiosaurus, near the anterior angle of the orbit.

The orbits are very large, and the sclerotic coat, or capsule of the eye, has in front an annular series of bony plates, which often occur in their natural position, and are beautifully displayed in many of the specimens in the Cases before us. This mechanism is not possessed by fishes, but is analogous to that observable in the eyes of turtles, lizards, and many birds; as, for example, in the owl and eagle: it confers on the eye additional power of adaptation, and intensity of vision.

The vertebræ, of which there are upwards of one hundred and forty in the individuals of some species, are, as we have already remarked, very short in their antero-posterior diameter (*i.e.* from front to back), and deeply cupped on each articulating face. The annular part is not united to the body of the vertebra, as in quadrupeds, nor connected by suture, as in Crocodiles, but terminates on each side in a compressed oval base, which fits into corresponding sockets placed on the boundary line of the spinal depression on the body, and thus completes the neural canal. The first and second vertebræ are anchylosed together, and have additional sub-vertebral, wedge-shaped bones, which render this part of the column a fixed point of support.[1]

The pectoral arch presents a remarkable resemblance to that of the Ornithorhynchus, or Duck-billed Platypus of New Holland. The episternum is of a triradiate form; the clavicles are strong, elongated, and slightly curved; the scapulæ are stout and broad, and in the form of a parallelogram; the coracoids are of a hatchet-shape, with a strong, thick, glenoid extremity, and a thin mesial expansion, which articulates with the episternal bone.[2]

The pelvic arch consists of the same elements as in the Plesiosaurus, but the *ischium* and *pubis* are much smaller than in that genus. The *ilium* is a short, simple, strong, and compressed bone, slightly expanding as it descends, to com-

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[1] This structure was first demonstrated by Sir Philip Egerton. See "Geol. Trans. Second Series," Vol. V. p. 187, Pl. XIV.

[2] See Dr. Buckland's "Bridgewater Essay," Pl. XII.

bine with the ischium and pubis to form the acetabulum, or socket for the femur. Professor Owen has directed especial attention to the fact, that "its upper or proximal end is not connected by synchondrosis to the extremities of the sacral ribs, but lies simply upon them, just as the scapula rests upon the ribs at the anterior part of the thorax. This is a condition of the ilium which is of great interest, and peculiarly characteristic of the Enaliosauria, among reptiles. It renders their pelvic extremities remarkably analogous to the ventral fins of fishes, which are in like manner simply suspended in the muscular mass, and not fixed to a sacrum."[1]

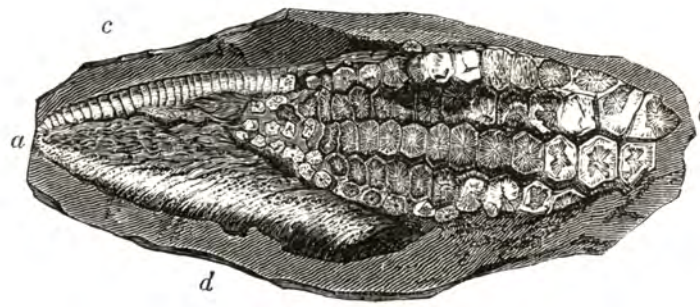
PADDLES, AND INTEGUMENTS.—The extremities or limbs of the Ichthyosaurus, with the general structure of those of the Plesiosaurus, have the humerus, femur, and the antibrachial bones, relatively shorter and broader. The carpus and tarsus are composed of polygonal bones, which are succeeded by several longitudinal rows of similar ossicles; and the remainder of the paddle is made up of a gradually diminishing series of the same character.

An unexpected light has been thrown upon the original structure of the paddles of the Ichthyosaurus, by the discovery of a specimen with remains of the integuments in a carbonized state; and so admirably preserved, as to demonstrate that the fin extended far beyond its osseous frame-work, and was bordered by cartilaginous rays, which bifurcated as they approached the margin.

Lign. 76, is a reduced figure of the hinder paddle of an Ichthyosaurus, (*I. communis*), with the integuments preserved, from the plate accompanying the original memoir on this fossil, in the "Geological Transactions." The specimen, which was discovered by Sir Philip Egerton, consists of the phalangeal bones of a posterior paddle, with the soft parts, or integuments, lying together in their natural position; *a*, marks the termination or distal extremity of the fin, consisting entirely of the carbonized integuments; these gradually widen and expand to receive the terminal rows of the phalangeal ossicles or bones, marked, *b*. The upper border of this soft

[1] "Brit. Assoc. Rep." 1839, p. 107. The admirable exposition of the osteological characters of the Ichthyosauri contained in this Report should be consulted by the palæontologist who is interested in the subject.

part of the paddle, *c*, is formed by a smooth, well-defined line, apparently a mere duplicature of integument. The lower margin, *d*, exhibits the remains and impressions of a series of rays, by which the fold of skin was supported, and these rays bifurcate as they approach the margin of the fin; it is inferred that these processes were either cartilaginous, or albuminous, like the horny tissue composing the marginal rays in the fins of Sharks. The Lias at Barrow-on-Soar, appears to have been peculiarly adapted to the preservation of the more perishable parts of animal tissues, for Dr. Buckland detected the dermal integument of an Ichthyosaurus in a specimen from that locality; and in the fine skeleton



LIGN. 76. HINDER PADDLE OF AN ICHTHYOSAURUS WITH ITS INTEGUMENTS. LIAS. BARROW-ON-SOAR.

(⅓ *nat. size.*)

(*From "Geol. Trans." Vol. VI. Pl. XX.*)

with four paddles, deposited in Wall-case *B*, p. 377, and which I obtained from Barrow, there were decided traces of the carbonized integuments around each paddle, but which were, unfortunately, chiselled away, in developing the bones, before I was aware of their true nature.

SKIN OF THE ICHTHYOSAURUS.—Remains of the *epidermis* or scarf-skin, and of the *corium* or true skin, of the Ichthyosaurus, were discovered, and first made known, by the Dean of Westminster, the Very Rev. Dr. Buckland, in his "Bridgewater Treatise."[1] These remains were observed in the inter-

[1] Dr. Buckland's "Bridgewater Essay," p. 23, Pl. X.

spaces of the ribs and sterno-costal arcs of a small Ichthyosaurus, now in the Oxford Museum.

"The spaces between these bones are covered with the remains of skin: the *epidermis* being represented by a delicate film, and the *rete mucosum* by fine threads of white carbonate of lime: beneath these the *corium*, or true skin, is preserved in the state of dark carbonate of lime, charged with black volatile matter of a bituminous and oily consistence. Similar black patches of skin are not unfrequently found attached to the skeletons of Ichthyosauri from Lyme Regis, but no remains of any other soft parts of the body have yet been noticed.

"The preservation of the skin shows that only a short interval elapsed between the death of the animal, and the interment in the muddy sediment at the bottom of the sea, of which the lias is composed."

There were no traces whatever of a scaly integument, and there is every reason to conclude that the Ichthyosauri had a naked skin, like the Cetaceans.

COPROLITES.—The excrementitious contents of the intestinal canal both of fishes, reptiles, and mammalia, occur in a fossilized state: those of the Enaliosaurians are found in great abundance in the lias of Lyme Regis, Street, &c. Before the true nature of these substances was detected and made known by Dr. Buckland, they were called *bezoar*-stones by collectors. They are often found occupying the abdominal cavity of the skeleton, as in the specimen in Wall-case *A*, Room IV. (see p. 376.)[1]

The state of preservation of the *Coprolites*, as these bodies are now termed, is such, as to show not only the nature of the food of the original animals, but also the dimensions, form, and structure, of the intestinal canal; and from the evidence thus obtained, we learn that these viscera in the Ichthyosaurus were convoluted spirally, as in some of the most voracious existing fishes. In the corresponding organs of Sharks, Dog-fish, (*Acanthias*,) and Rays, the interior of part of the intestinal tube is spirally coiled; an arrangement by which the extent of surface of the mucous membrane is greatly increased, and the consequent

[1] See Dr. Buckland's "Bridgewater Essay," Pl. XV.

absorption of nutriment from the food, in its passage through the canal.[1]

SPECIMENS OF ICHTHYOSAURI IN THE BRITISH MUSEUM.—The collection of Ichthyosauri in Room IV. comprises eight or nine recognised species, which have been rigorously examined and carefully determined by Professor Owen. From the length to which our general observations on the organization of these reptiles have extended, a concise notice of the species will suffice; and the annexed tables of the order in which the specimens are arranged, will enable the visitor to refer to a particular fossil with but little trouble.

There are about thirty very fine specimens in the Gallery; including the most interesting of the separate crania, paddles, vertebral columns, &c.; besides a great number of isolated bones, parts of skulls and jaws, coprolites and other remains of Ichthyosauri.

WALL-CASE A. [1.]

On the Top. Ichthyosaurus tenuirostris.

A small beautiful cranium, and one paddle.	Ichthy. intermedius. (Hawkins, Pl. XX.)	Ichthyosaurus with *coprolite* in the abdominal region. Jaws with teeth; very beautiful. (Hawkins, Pl. XIX.) (Hawkins, Pl. IX.)

Fine skull and vertebral column, ribs, &c. with paddles, of Ichthyosaurus longipennis.

Ichthyosaurus communis, with anterior and posterior paddles. (Hawkins, Pl. VII.)

ICHTHYOSAURUS TENUIROSTRIS[2] (*Conybeare*).—*Wall-cases A, D,* and *E.*—Of this species there is a specimen in Wall-case *A;* a fine cranium and jaws, with the spinal column, many bones of the trunk, and paddles, in Wall-case *E;* two imperfect specimens, and a small beautiful cranium in the left hand compartment of the same Case.

The Ichthyosaurus *tenuirostris* is characterized by the great length and slenderness of the jaws, which resemble in this respect the maxillary organs of the Gavial or Teleosaurus. The length of the snout is produced by the prolongation of

[1] See Dr. Buckland's "Bridgewater Essay," p. 193.
[2] "Brit. Assoc. Reports," 1839, p. 117.

the intermaxillary bones, and of the dentary bones of the lower jaw. The malar bone is remarkably long and slender. The cranium is flat, and the orbits are very large.

The teeth are slender; there are from 60 to 70 on each side the upper jaw, and 60 on each ramus of the lower jaw.

The anterior extremities or paddles are much larger than the posterior pair, and very strong and massive. The shafts of the humerus and femur are relatively long, and their distal ends broad.

This species, according to the known specimens, attains a length of thirteen or fourteen feet; the largest teeth are $1\frac{1}{2}$ inch in length. It was named *Ich. chirostrongulostinus*, (signifying round-boned-paddle) by Mr. Hawkins; and is figured in Pl. XV. XVI. of his work.

WALL-CASE B. [2.]

On the Top.	Two paddles and detached bones.	Ichthy. intermedius, ribs and vertebral column.	Skull and jaws of Ichthy. longipennis.

Upper Shelf. Miscellaneous specimens of detached parts.

Hawkins, Pl. XII.	Ichthyosaurus intermedius: a beautiful fossil; the cranium and jaws, spinal column, &c. the large anterior, and small posterior, pair of extremities. (Hawkins. Pl. XVII.)	Several small specimens of Ichthyosaurian remains.
Cranium, trunk, and four paddles; very fine: from Street.		Ichthy. intermedius. Hawkins Pl. XVIII.
Various small specimens.	Cranium, trunk, spinal column, and two left paddles of Ichthyosaurus.	Beautiful head and jaws.

ICHTHYOSAURUS INTERMEDIUS[1] (*Conybeare*).—*Wall-cases A, B,* and *E.*—The beautiful example of this species, figured in Mr. Hawkins's work, Pl. XX. is placed in Wall-case *A*.

In Case *B*, there is a splendid specimen, seven feet long, from Street, with the vertebral column gently arched, and the four paddles entire. It is figured in Mr. Hawkins's Memoir, Pl. XVII.

A skeleton, six feet long, showing the upper surface of the cranium and spinal column, with the four paddles exquisitely displayed, is in the lowermost compartment of Case *E*.

The name given to this species by Mr. Conybeare, is indicative of the intermediate character of the teeth, which are

[1] "Brit Assoc. Reports," 1839, p. 120.

"more acutely conical than in Ichthyosaurus communis, and the striæ less prominent; but are less slender than in Ich. tenuirostris." There are other characters, alike intermediate between those of the above-named species, but which would be unintelligible to the reader, without figures. "The maxillary portion of the skull is relatively shorter, and converges more regularly to the snout, than in Ich. communis; and the teeth are longer, more slender and numerous.[1] In a skeleton in Mr. Johnson's museum at Bristol, there were $\frac{40-40}{35-35}$." The number of vertebræ exceeds 125. The orbit is large, and has 16 or 18 sclerotic plates.[2]

This Ichthyosaurus does not exceed seven feet in length; it is the most common species, and its remains are very generally distributed throughout the Lias of England.

ICHTHYOSAURUS LONGIPENNIS.—*Wall-case A.*—The fossil thus labelled, is from the Lias of Whitby, in Yorkshire. It consists of a cranium with the jaws and teeth, a confused mass of the anterior part of the trunk, a few bones of one fin, and a nearly perfect paddle, the humerus of which is short and very strong. The carpals, metacarpals, and digitals, comprise thirty rows of ossicles; the fin must therefore have been very long and tapering, if the present bones are the normal number; but it seems probable that the paddle was wider in proportion to its length, and that many ossicles are lost. I am not aware of any published description of this species.

ICHTHYOSAURUS COMMUNIS[3] (*Conybeare*).—*Wall-cases A* and *D.*—Of this species there is a most beautiful specimen with the anterior and posterior paddles, in the lowermost compartment of Case *A*,[4] and another nearly perfect skeleton in the upper division of Case *D.*

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[1] Prof. Owen in "Brit. Assoc. Rep." p. 110, which the scientific inquirer should consult for anatomical details.

[2] This species is named by Mr. Hawkins *chiroparamekostinus*, (or oblong-boned paddle,) from the oblong form of the phalangeal ossicles; a character which, however, is not peculiar to this species. See "Memoirs on Ichthyosauri," p. 32.

[3] "Brit. Assoc. Rep." 1839, p. 108.

[4] I cannot resist the insertion of the following racy account of the discovery and exhumation of this exquisite fossil. One Jonas Wishcombe, a fossil dealer, of Charmonth, had perceived the remains of an enormous Ichthyosaurus at low water, but in a situation so unfavourable

The skull of this species is wide behind, and rapidly contracts to the base of the jaws, which are prolonged and sub-com-

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for its extraction, being always covered with water, except for a brief interval at the very lowest tides, that its removal appeared impossible, and he willingly sold his right to the discovery to Mr. Hawkins. It was upwards of a month after the purchase of this treasure of the deep, before the tide was sufficiently low to allow of its being visible—we will now leave Mr. Hawkins to tell the story:—

"The best street of Lyme Regis is disfigured—but all the world knows this—by an ugly market place, which has an ugly tower, surmounted by an ugly fish to tell the way of the wind. To this most ungainly place and puppet of a tower were my eyes directed with the first sunbeam, and to the weather-cock my orisons went thrice seven days in vain: there it stuck, with its mouth agape, as if to bugbear the violent wind and storm, which blew all the time from the south and west. Every day for upwards of three weeks I sought with a kind of forlorn hope from the lofty cliffs, the sandstone rocks.

"One day I arose in such imperturbable mood as disappointment like this may be supposed to occasion, and gaped to see the brazen fish turn tail, as much as he himself did at the hollow tempest that flitted by from the rugged north. The weather had veered to the right quarter at last, and if it continued a few hours I might accomplish my long deferred hope: all my friends congratulated me. 'Make haste, the tide's going out fast,' said Miss Anning, as I passed her on the way to the Ichthyosaurus.

"Half a dozen of us, all lusty and eager for the occasion, meet: we arrange the mode of exhumation, dispose our instruments, and wait the crisis when the returning waves shall desert the remains It arrives—'let no one invade this'—a square marked around the skeleton in the marl, six feet and a half by three and a half. 'What d'ye think, Zur, to dig un out a wheal,' exclaimed the Atlean Blue—the best tempered but unhappily bacchanal fellow that ever lived. 'Yes.'—The tide goes back—back—back—our square is cut ten inches deep; I lessen its length and breadth a foot:—'The crow-bars and pick-axes to loosen it from its bed: now, my boys, now—now: does it come up in one piece?' 'Yeas, Zur.'

"The spectators say the tide flows—it does: we attempt to raise the heavy mass upon its side, but our strength fails us—''tis more than we can accomplish.' Assisted by several gentlemen who were spectators, it is at length removed from its situation—'the tide flows fast'—we try to lift it into the vehicle prepared for its transport from the reach of danger—we cannot. 'You must break un in half, Zur.' 'No.' The waters approach us—they make a breach in the rude bank cast up by us against them—another billow and yet another—they are at our heels: 'One more trial, my boys, your own reward, if successful—ye-o'—the *saurus* is safe! When that beautiful thing, of which our beautiful plate is but a faint type, came forth at the magic touch of my chisel, such a feeling possessed me as few can ever realize!"—*Hawkins's "Memoirs of Ichthyosauri," &c.*

pressed. The teeth are relatively large, round, conical, and longitudinally furrowed, the base being expanded and deeply grooved; there are from 40 to 50 on each side the upper, and from 25 to 30 on each ramus of the lower jaw.

The anterior paddles are three times longer than the posterior pair, and are proportionately broader, and contain a greater number of ossicles, than in other species. This character induced Mr. Hawkins to change the specific name to *chiropolyostinus*, (or many-boned paddle.[1]) There are eight metacarpal bones, and two hundred and twelve digital ossicles. The humerus is relatively shorter and stouter than in any other species.

Professor Owen considers that each anterior paddle of this species has an additional series of digits, and about 50 more phalangeal bones, than that of the Ich. intermedius, the entire breadth and the power of the anterior fins being thereby increased.

There are 17 sclerotic plates in each eye; the orbit and eye are relatively smaller than in Ich. tenuirostris.

This is one of the larger species of the genus, some specimens indicating a total length of 14 feet.

The specimen in Case *A*, which is figured by Mr. Hawkins in Pl. VII. shows the fractured or dislocated state of the tail, at about one-fourth of the length from its distal extremity, which Professor Owen supposes is connected with the presence of a large tegumentary caudal fin: and the laterally compressed form of the terminal caudal vertebræ, first ascertained by Sir Philip Grey Egerton, is presumed to afford additional demonstration of the existence and direction of such an organ.[2]

ANGLE BETWEEN WALL-CASES A & B.

Part of the series of bones of a paddle of Ichthyosaurus platyodon.

Portion of an enormous cranium of Ichthyos. platyodon. | Hawkins, Pl. VIII.

Magnificent cranium and jaws, and part of the spine of Ichthyos. platyodon.

Various specimens of paddle bones, &c.

ICHTHYOSAURUS PLATYODON[3] (*Conybeare*).—*Wall-cases B* and

[1] Hawkins's "Memoir," p. 25, Pl. VII. X.
[2] See "Brit. Assoc. Reports," p. 87.
[3] Ibid. 1839, p. 112.

C.—Of this gigantic species there is one magnificent example, and several very fine detached crania and jaws, paddles, &c.

A series of carpal bones of an enormous paddle, is placed in the angle uniting Cases *A* and *B*: in the same division there is a portion of a stupendous cranium and jaws, with the teeth beautifully preserved; and beneath, a splendid skull, 4½ feet long, with the zone of sclerotic plates entire; this fossil is figured in "Philos. Trans." for 1814.

WALL-CASE C. [3.]

On the Top.	Vertebræ and ribs: detached bones imbedded in lias.	Ichthyosaurus platyodon, *var. immanis.* Enormous jaws, and detached bones of the trunk and spinal column.

Skeleton of Ichthyosaurus platyodon, 18 feet long; consisting of the skull with the jaws and teeth, the spinal column composed of upwards of 90 vertebræ, and three of the paddles. (Hawkins, Pl. III.)
A small skeleton presented by Mr. Broderip.

Separate bones of the spinal column of an Ichthy. platyodon, amounting to upwards of 100 vertebræ.

The magnificent skeleton of Ich. platyodon, in Wall-case *C*, is a noble monument of the zeal, skill, and patience of Mr. Hawkins, by whom it was literally "snatched from the devouring ocean," and developed and restored.[1]

[1] When this stupendous fossil first arrived at the British Museum, together with the other specimens purchased of Mr. Hawkins for a sum awarded by Dr. Buckland and myself, much misapprehension was entertained by the Curators as to the genuineness of these splendid specimens, in consequence of some portions of this skeleton having been restored and coloured so as to resemble the original bones; and a report was quickly in circulation that the valuers had been deceived, and had awarded a sum for the collection far beyond its real value.

This supposition was altogether erroneous; the unequalled magnitude of this specimen—the circumstances under which it was found imbedded—the great difficulty of extracting it from the stratum—the expense, the time, the labour, the trouble, of repairing it—setting aside the skill and experience required to conduct the operation successfully, were, in my opinion, but inadequately remunerated by the sum of 210*l.* given for this unique specimen, which is one of the choicest treasures in the British Museum.

That the reader may have some idea of the circumstances under which this matchless fossil was obtained, I will give, in Mr. Hawkins's own language, an account of the exhumation of this saurian of the ancient world from the bed of its native ocean, and its rescue from the billows

This fossil is exposed so as to show the dorsal aspect of the skeleton from the tip of the muzzle to near the extremity of the tail. The cranium, the vertebral column and ribs, and the bones of three paddles, are clearly displayed.

This is the most gigantic of the known species of Ichthyosaurus, and attains a length of 30 feet; the orbit, in some

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"of the sea that rolled over its petrified remains, and threatened their destruction.

"In the month of July, 1832, Miss Anning obtained from the lias limestone near the church at Lyme, part of the head of the Ichthyosaurus Chiroligostinus," (the large specimen in Case *C*.). "Happening to arrive at Lyme the same day, I was fortunate in availing myself of the specimen. Accompanying Miss Anning the next morning to the beach, she pointed out to me the place whence it was brought. Persuaded that other portions of the skeleton must be there, I advised its extrication; this Miss Anning deemed impossible, and left me at liberty to make the attempt.

"If our reader knows Lyme, he will remember that four or five hundred yards of the coast from the borough eastward, has an elevation of from 60 to 100 feet above high water mark, and that a bed of diluvial gravel conceals the blue marl of the lias from observation, except in those places where the waters have ploughed a channel towards the sea. At this spot there was a peninsular rock that had long defied the fury of the destructive current that a south-wester invariably propelled against it from the Cob. There it abutted against the angry waves, and resisted the power of the surge. Beneath this rock was the Chiroligostinus.

"But that venerable tiny promontory is no more. What the warring elements failed in, curiosity achieves: the hand of man came upon it, and it departed like a shadow.

"The sun rose bright on the 26th day of July, 1832; and the morning mists were hardly rolled away from the hill-side, ere many men busily engage with spade and pick-axe to humble the doomed summit of this cliff. Progress was also made on the following day, when people from the adjacent country flocked to witness the execution of a purpose which seemed to stagger their faith in our sanity. By next day's noon twenty thousand loads of earth cast from the crown of the rock constitute a good road-way to the beach from that part of it to which we had dug, and a few minutes more suffice to lay bare the wonderful remains! *My* eyes the first which beheld them! But, alas! the bones with the marl in which they lay, broke into small fragments, so that I almost despaired of their reunion. At length all was secured; the skeleton and its matrix weighed a ton. When my manual labours terminated, it counted about six hundred pieces, some of which were so brittle that it was dangerous to touch them. These a trusty Lucchese under my especial direction fixed in sulphate of lime, of which three thousand pounds were used, in a case that weighed half a ton!"—*Hawkins's "Memoirs on Ichthyosauri,"* p. 13.

specimens, is 1 foot in diameter, and the teeth $2\frac{1}{2}$ inches in length. There is a scapula in the collection 17 inches long, and 9 inches broad at the distal end; and vertebræ 6 inches in transverse diameter.

The teeth are distinguished from those of the other species by the form of the crown, which is conical and subcompressed, and has a sharp ridge on each side; the base is not grooved as in the teeth of I. communis: these dental characters suggested the specific name. The numbers of the teeth are $\frac{45-45}{40-40}$.

The head is relatively longer in proportion to the trunk than in I. communis and I. intermedius. The lower jaw is remarkably massive and powerful, and projects further backwards beyond the joint, than in the preceding species.[1]

The vertebræ are about 120 in number; their bodies are more compressed than in the other species.

The anterior and posterior paddles are equal in size, more simple in their structure, and composed of fewer bones, than the extremities of the species previously described. This structure, first pointed out by Mr. Hawkins, induced that gentleman to name the species *chiroligostinus* (signifying few-boned-paddle).

The humerus is short in relation to its breadth: the femur is proportionately longer than in other species. Professor Owen remarks, that the small number of digital ossicles in the extremities of this gigantic Ichthyosaurus, and the greater distances at which they are placed from each other in the lower half of the paddle, indicate "that the ligamentous substance which connected them together, entered more abundantly into the composition of the fin."

WALL-CASE D. [4.]

On the Top.	Vertebral column and paddle. (Hawkins, Pl. XXI.)	Fragmentary specimens of Ichthy. intermedius.	Fragmentary specimens.

Two exquisite skeletons of Ichthyosaurus communis. (Hawkins, Pl. XII.)

Ichthyosaurus lonchiodon: a large specimen, comprising the cranium and jaws, the vertebral column and ribs, and one of the anterior, and one of the posterior extremities.

[1] "Brit. Assoc. Rep." 1839, p. 116.

ICHTHYOSAURUS LONCHIODON.[1]—(*Owen.*)—*Wall-case D.*—A fine skeleton of this species, fifteen feet in length, with the skull and jaws, one anterior and one posterior paddle, is deposited in Wall-case *D*; the spinal column, consisting of upwards of 120 vertebræ, remains, but part of the tail is deficient. This specimen is from Lyme Regis, and was obtained by Miss Anning. The teeth, as implied by the specific name (*lonchiodon*, signifying lance-shaped), are more slender in proportion to their length than in I. communis, or I. platyodon, and straighter than in I. tenuirostris, or I. intermedius. Their base is cylindrical, and regularly fluted; the transverse section of the crown is nearly circular, not compressed, as in I. platyodon. The paddle is relatively less than in the last named species.

But the great interest of this fossil consists in the preservation of the elements of the *os hyoides*, which are seen in their natural relative position between the rami of the lower jaw; these parts of the structure of the Ichthyosaurus were first detected by the illustrious Cuvier.[1]

The hyoid bones in the skeleton before us are thus described by Prof. Owen :—

"The cornua are robust, elongated, sub-prismatic bones, slightly enlarged and truncate at both extremities; their junction with the small flattened hyoid body seems to have been by means of abundant flexible ligamentous material; the length of each cornu is a fifth part that of the lower jaw.

"The condition of the hyoid apparatus in the Ichthyosaurus, besides corroborating the evidence afforded by the rest of the skeleton, that this extinct reptile was an air-breather, indicates that its tongue was almost as little developed as in the Crocodile; and since the Ichthyosaurus obtained its food at all times under the same circumstances which necessitate the modification of the hyoid apparatus in the Crocodile, it may be inferred that the hyoid arch was physiologically related to the working of a similar valvular apparatus for defending the orifice of its air-tube from the water admitted into the interspace of the jaws, during the capture and slaughter of its prey; and the structure and the relative position of the hyoid apparatus corroborates this inference."[2]

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[1] "Os. Foss." tome v. p. 465.
[2] "Brit. Assoc. Rep." p. 98.

WALL-CASE E. [5.]

On the Top.	Ichthyosaurus: the cranium, one paddle, and many displaced bones of the trunk.
Ichthy. intermedius: skull, and paddles.	Ichthyosaurus tenuirostris: the skull, spine, and paddle-bones.
Ichthy. tenuirostris: two imperfect specimens.	Ichthyosaurus longirostris: a fine cranium, vertebral column, many bones of the trunk, and paddles.
Ichthy. latifrons: portion of vertebral column, &c.	Ichthyosaurus intermedius: an exquisite skeleton: the skull and four paddles, and the entire vertebral column, &c.

ICHTHYOSAURUS LONGIROSTRIS. — *Wall-case E.* — In the middle compartment of Case *E* there is part of the skeleton of an Ichthyosaurus from Whitby, about six feet in length. It is remarkable for the exceedingly slender and elongated muzzle; the skull is crushed; and with the exception of the chain of vertebræ which extends to the tail, and a few bones of one paddle, there are no characteristic parts preserved. The specific name, longirostris, is affixed to this specimen; but I cannot ascertain that it is figured or described.

ICHTHYOSAURUS LATIFRONS.[1]—(*König.*)—*Wall-case E.*—The mutilated cranium, with a large foramen on the top of the head between the orbits, and attached to a considerable portion of the vertebral column, deposited in Case *E*, is figured and described by Mr. König in his "*Icones Sectiles*," Pl. XIX., under the name of *Ichthyosaurus latifrons*. This specimen is characterised by the great breadth of the fore part of the cranium, and the large size of the parietal foramen. The periphery of the vertebræ is flatter than in those of other species; but I am not aware that other specimens have been found with a similar character. The upper portion of the circle of sclerotic plates remains in the orbit.

RETROSPECTIVE SUMMARY.—From the data afforded by the remains of the trees and plants, and of the herbivorous and carnivorous reptiles, imbedded in the fluviatile deposits of the south-east of England, described in the previous chapter, we endeavoured to determine the physical conditions, and the

[1] "Brit. Assoc. Rep." 1839, p. 122.

nature of the flora and fauna of the islands, and continents, of the secondary geological epochs.

The fossil relics of the inhabitants of the seas of the same remote periods occur in such profusion, as to supply ample materials for the restoration of the swarms of living things that peopled the waters, through the countless centuries during which the liassic, oolitic, Wealden, and cretaceous formations were deposited.

A fanciful representation of a gulf of the liassic ocean, swarming with zoophytes, cephalopodous mollusca, and fishes, with Ichthyosauri sporting on the billows, and devouring their prey with uplifted jaws, and Plesiosauri skimming the surface of the deep, and seizing pterodactyles by their "leathern"[1] wings, is probably familiar to most of my readers; for a *jeu d'esprit* of an eminent geologist, privately circulated soon after the true characters of those marine reptiles were made known, was lithographed and published as a faithful delineation of the fish-like lizards, and swan-necked saurians, that inhabited the seas of the liassic ages.

The structure and economy of the Plesiosauri, as sketched by the vigorous pen of their original interpreter, Mr. Conybeare, have already been fully considered; those of the Ichthyosauri are portrayed by the illustrious Cuvier, in characters not less graphic.

The Ichthyosaurus was a reptile having a moderate tail, a large head, with a very short neck, a long pointed muzzle, and jaws armed with numerous conical teeth. Two eyes, of enormous bulk, imparted to the head a physiognomy altogether peculiar, and this great development of the organs of sight endowed the animal with nocturnal vision. It is probable that it had no external ear, and that the tympanic bone was covered by the skin, as in the chameleon.

The Ichthyosaurus respired air from the atmosphere, and not through a watery medium like fishes; it must, therefore, have risen frequently to the surface of the sea to breathe, like the cetaceans. Its short, flat, undivided limbs, were adapted only for progression through the water, and could have admitted but of very feeble locomotion on the land.

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[1] *Leathern* wings of Pterodactyles,—for the authority, see Prof. Owen, cited *ante*, p. 193.

It existed in seas peopled with extinct species and genera of fishes, and teeming with mollusks allied to the cuttle-fish and the nautilus, but of types that perished at the close of the cretaceous period. Groves of corals and of other zoophytes, related to forms now of excessive rarity, even in tropical seas, clothed the bottom of the deep; and echinoderms, star-fishes, crustaceans, and other tribes of invertebrata, were included in that prodigious assemblage of extraordinary forms of being, which constituted the population of the liassic ocean. Shoals of turtles inhabited those waters, and many kinds of crocodilian reptiles frequented their shores.

Such was the marine fauna in which the Ichthyosauri and Plesiosauri held the highest place; such the inhabitants of that ocean whose waters surrounded the islands, and washed the shores of the continent, that were tenanted by the stupendous terrestrial herbivorous and carnivorous lizards, whose fossil relics formed the subject of our previous investigations: and amidst those multitudes of reptilian forms, that traversed the air, or crawled on the earth, or sported in the seas, two diminutive genera of quadrupeds were the sole representatives of the Mammalia, either on the land or in the waters.

CHAPTER IV.

PART III.

FOSSIL REMAINS OF RUMINANTS.

DILUVIUM OF THE VALLEY OF THE THAMES—FOSSIL BOVIDÆ—BISON PRISCUS —BOS PRIMIGENIUS—BOS LONGIFRONS.

DILUVIUM OF THE VALLEY OF THE THAMES.—The banks of the Thames and of its tributary streams, are in great part composed of an ancient alluvial silt, or brick earth, many yards in thickness, which contains, in some localities, great numbers of fossil bones of Mammalia, of many extinct, and some recent species, with existing kinds of land and river shells. Among the latter there is a freshwater bivalve, a species of *Cyrena*, which is supposed to be identical with one that abounds in the river, at Alexandria; and an *Unio*, of which the living analogue inhabits the lakes of Auvergne in France.[1]

At Erith, on the south bank of the Thames, a spot well known for its beautiful sylvan scenery, this deposit attains an elevation of 40 feet above the level of the river; and at Maidstone, (*ante*, p. 302,) it is 60 feet above the Medway. At Grays, in Essex, opposite Gravesend, there are extensive cuttings of these deposits in the brick-fields, in which the following section is exposed. 1. Gravel and sand. 2. Loamy sand and brick-earth. 3. Ferruginous sand, shells, and gravel. 4. The Chalk, which is the foundation rock of the country.

From this locality alone have been obtained bones of the

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[1] See a highly interesting communication on these deposits, by John Morris, Esq. (of Kensington); "Magazine of Nat. Hist." vol. ii. p. 539.

Elephant, Rhinoceros, Hippopotamus, Horse, Deer, Ox, Irish Elk, Bear, Hyæna, Vole, &c.

From Grays and Ilford in Essex, the fossil bones of ruminants in Wall-case *F* were chiefly obtained.

The specimens in this Case are too miscellaneous to admit of particular description, until they are properly arranged and numbered. They comprise skulls, jaws with teeth, and bones of the extremities, of Deer, Elk, Ox, &c. The only fossils that can be conveniently selected for description, are the crania and horns of the three species of Bos or Ox, whose remains are very generally distributed throughout the post-pliocene or diluvial deposits of Europe; and also in the bone-breccia, and in the ossiferous caverns.

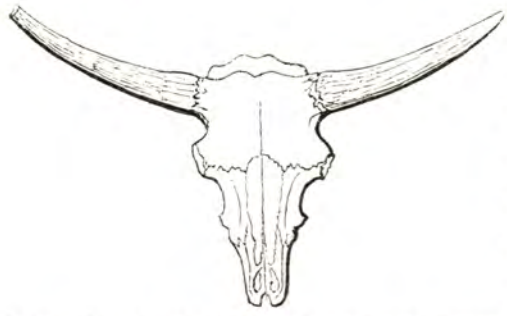
Fossil Bovidæ, or Oxen.—Distinguished from other ruminants by their strong and massy head, armed with horns having a cavernous core or pith, and extending laterally from the skull, the crania of the Bovidæ are easily recognised. Their molar teeth, the crowns of which, as in the other ruminants, have double crescents, the convexity in the upper molars being internal, and in the lower external, are readily distinguished from those of the Elk and Deer, with which they are often intermingled, by the presence of a little column or pillar between the ridges of the crown, and which is of sufficient length to be worn down in common with the crescents, by mastication.

There are the remains of three well-known fossil species of Ox in this collection; and it is an interesting fact, that one of the species still exists, and that the others in all probability have died out, within the last thousand, or fifteen hundred years.

M. Pictet remarks, that the Aurochs are the only bovine animals ancient tradition assigns to Europe, and that their fossil remains prove they lived from a very remote antiquity; there is also another species, which is apparently the ancestor of our domestic Ox. Bones of this family are found in the upper tertiary or pliocene deposits of Montpellier, and Puy-de-Dôme; and in the eocene of the Sewalik or Sub-Himalayan hills.

Bison Priscus; or Fossil Auroch.—*Wall-case F*, and *Wall-case in Room V.*—In the Case before us there are several horn-cores, and on the top of the Case in Room V. a

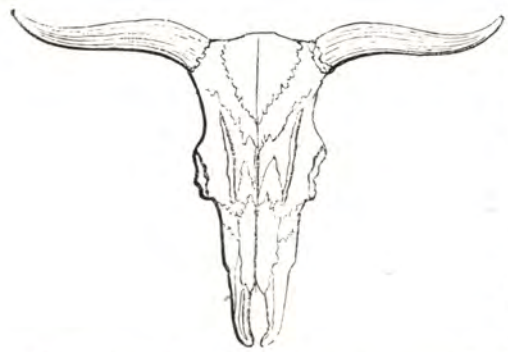
fine cranium and horn-cores, of the great fossil Auroch or Bison; a species, according to Professor Owen, that except in its larger size, and in having longer and somewhat less bent horns, presents no satisfactory specific distinction, compared with the bones of the existing Lithuanian Auroch,[1] of which a living pair were lately exhibited in the Zoological Gardens, in the Regent's Park.[2]



LIGN. 77. SKULL AND HORN-CORES OF BISON PRISCUS. Front view.
($\frac{1}{20}$ *nat. size.*)

The Lithuanian Auroch, which has been preserved from extinction solely by the protective laws of the Emperor, appears to have abounded in the forests of Europe when the Romans extended their conquests to the north, and overran Germany.

The skull in the subgenus Bison or Auroch, differs from that of the Bos or Ox, in the convexity and greater breadth of the forehead, and in the horns being placed more anteriorly in relation to the supra-occipital ridge, and in the obtuse angle, and semicircular form of the occipital plane.



LIGN. 78. SKULL AND HORN-CORES OF BOS PRIMIGENIUS. Front view.
($\frac{1}{20}$ *nat. size.*)

There is a cranium in the Museum, from Dantzig, which was described and figured by Klein in the "Philosophical Transactions."

BOS PRIMIGENIUS, OR GREAT FOSSIL OX. — *Wall-case F, Room V.*— This fine skull, with its horn-cores nearly entire, is from

[1] "Brit. Foss. Mammals and Birds."

[2] Presented by the Emperor of Russia; in compliance with the solicitation of Sir Roderick Murchison.

the alluvial deposits near Athol, in Perthshire. It is figured and described in "British Fossil Mammals,"[1] and I would refer the scientific inquirer to that work for a full exposition of its character and specific affinities: a brief notice will here suffice. "The concave forehead with its slight median longitudinal ridge, the origin of the horns at the extremities of the sharp crest which divides the frontal from the occipital regions, the acute angle at which these two surfaces of the cranium meet to form the above ridge,—all identify this specimen with the *Bos primigenius* described by Cuvier, Bojanus, and Fremery."[2]

This skull is one yard long, and the span of the horns three feet six inches. The breadth of the forehead between the horns is $10\frac{1}{2}$ inches.

The remains of this gigantic Ox are not uncommon in the alluvial deposits of Scotland; as my friend Dr. Fleming, the distinguished Professor of Zoology in the New College of Edinburgh, pointed out 25 years ago.[3] In England similar remains have been found in many localities; but this species appears to have been more abundant in Scotland down to a comparatively recent period; and therefore it may be concluded that the *Bos primigenius* maintained its ground longest in Scotland, before its final extinction.[4]

The remains of this species have been found in British tumuli, and also among the rejectamenta of Roman encampments. This large species of Ox, and its contemporary the Auroch, above described, doubtless inhabited these Islands, and the Continent of Europe, when the aboriginal human tribes first took possession of the land; and both have gradually become extinct.

Cuvier, and other eminent naturalists, regard this species as the origin of our domestic cattle; but Professor Owen is of opinion that the evidence is in favour of our herds being the

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[1] "Brit. Foss. Mammals," p. 498.

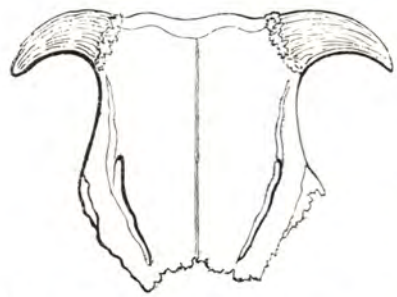
[2] Ibid. p. 501.

[3] "British Animals," Edinburgh, 1828, p. 24.

[4] An almost entire skeleton of the Bos primigenius was obtained from the alluvial deposit overlying the London clay at Herne Bay, and is now in the collection of Mr. Wickham Flower. The length of each horn-core in this specimen is 3 feet 3 inches along the outer curve; and the circumference at the base $18\frac{1}{2}$ inches. See "Brit. Assoc. Rep." 1843, p. 233.

descendants of a smaller primitive wild species of Bos, characterized by its long frontlet and short horns; of which there are part of a skull and horn-cores, and some detached bones in the Museum.

Bos longifrons (*Owen*).—*Wall-case F.*—The horns and skull of this species of Ox appear to have been first described from specimens found in the bogs of Ireland.[1] Similar remains have been obtained from the alluvial deposits of the valley of the Thames. In 1822, I received from G. B. Greenough, Esq. a horn of this species from Walton, in Essex, together with fragments of the antlers of the Irish-Elk, and horns of the great Auroch, which were found with it.



Lign. 79. Skull and horn-cores of Bos longifrons. Front view.[2]

($\frac{1}{10}$ *nat. size.*)

The length from the supra-occipital ridge to the nasal bones is 8 inches; the breadth of the forehead $6\frac{1}{2}$ inches; span of the horn-cores from tip to tip 1 foot; length of the horn-core 4 inches.[3]

But independently of this disparity in size, the *Bos longifrons* differs from the great *Bos primigenius*, by the smallness, shortness, and different form of the horns.

That the *Bos longifrons* was abundant in England during the Roman period, is proved by the occurrence of skulls and horns, and other parts of the skeleton, in several localities associated with remains of Roman art; as at Colchester, in 1849.[4]

I will conclude this notice with the following remarks of the Hunterian Professor on the question as to the species of Bos, from which the domestic breed has probably originated.

"In this field of conjecture, the most probable one will be

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[1] Oper. cit. p. 511.

[2] From Professor Owen's figure of a specimen from Ireland. "Brit. Foss. Mamm." p. 508.

[3] I have a specimen of a horn-core attached to a portion of the frontlet, which is $5\frac{3}{4}$ inches long. It was dredged up off the Essex coast with teeth of Elephants, and presented to me by Lord Londesborough.

[4] See "Archæological Journal."

admitted to be that which points to the *Bos longifrons* as the species that would be domesticated by the aborigines of Britain before the Roman invasion. Had the *Bos primigenius* been the source, we might have expected the Highland and Welsh cattle to have retained some of the characteristics of their great progenitor, and to have been distinguished from other breeds by their superior size, and the length of their horns. The kyloes and the runts are, on the contrary, remarkable for their small size, and are characterised either by short horns, as in the *Bos longifrons*, or by the entire absence of these weapons."[1]

From what has been advanced, we may conclude that three well characterised types of Bovidæ existed in great numbers contemporaneously with the extinct species of Elephants, and other pachyderms, and were not extirpated till within a comparatively recent period; their remains occur in the most ancient post-pliocene deposits, and in the peat-bogs, and debris of existing marshes and rivers: they form therefore a link between the present and the past, uniting the extinct mammalian faunas with those of modern times.

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[1] "Brit. Fossil Mammals," p. 514.

CHAPTER IV.

PART IV.

FOSSIL CARNIVORA OF THE CAVERNS.

FOSSIL CARNIVORA OF THE CAVES—CAVE OF GAILENREUTH—FOSSIL BEARS OF THE CAVERNS—URSUS SPELÆUS—URSUS PRISCUS—MACHAIRODUS—MACHAIRODUS LATIDENS, FROM KENT'S CAVERN.

FOSSIL CARNIVORA OF THE CAVERNS.—The fossil bones and teeth of numerous species of *Carnivora*, as the Lion, Tiger, Bear, Cat, Dog, &c. abound in fissures and caverns, in breccias and conglomerates, and in drifted sand and gravel. The remains of the large Pachyderms and Ruminants are for the most part found buried in the superficial alluvial deposits; but those of the carnivora, although occasionally entombed with the herbivora in Drift, are generally imbedded in the floors of extensive fissures or caverns in stratified rocks. In some instances, such immense quantities of bones and teeth of individuals of all ages, and belonging to but one or two species occur, as to render it probable that these caves were for a long period the dens of the extinct species of Bears, Wolves, Hyenas, Tigers, &c. whose bones they enclose.

Another remarkable geological condition in which fossil carnivora occur, is that of an ossiferous, or *bone-breccia;* that is, a conglomerate formed of fragments of limestone and bones, cemented together into a hard rock, by a reddish calcareous concretion. This breccia is found in almost all the islands on the shores of the basin of the Mediterranean Sea; as for example, at Gibraltar, Cette, Nice, Cerigo, Corsica, Palermo, &c.

The most celebrated ossiferous caverns are situated in Franconia, and in numerous parts of the Hartz. That of Gailenreuth has long been known and frequented for its fossil treasures, which principally consist of the bones and teeth of extinct species of bears; skeletons have been found of animals of all ages, from the adult to the cub but a few days old.[1] There are numerous caverns in the neighbouring district, some of which are equally rich in the remains of carnivora;[2] fossils of a like nature are also found in the consolidated gravel and drift of various parts of Germany, and in the fissures of rocks containing iron-ore, at Kropp, in Carniola.

In Australia, caverns with ossiferous breccia are numerous; but the bones belong to extinct marsupial animals of genera still existing in the country: while in the New Zealand caves, the bones hitherto obtained are those of the Moa and other extinct colossal brevipennate birds, (*ante*, p. 104.)

Ossiferous Caves of England. — In England, several caverns presenting similar phenomena have been discovered. That of Kirkdale, near Kirby Moorside, Yorkshire, is well known from the celebrity it acquired by the description and illustration of its contents by Dr. Buckland.[3] This cave, or rather fissure, for its dimensions were too limited to merit the name of cavern, was situated in oolitic limestone; it was two hundred and fifty feet long, from two to fourteen high, and six or seven wide. The floor was occupied by a bed of indurated mud, covered over with a thick crust of stalagmite; the roof and sides being invested with a sparry coating, as is commonly the case in the fissures of limestone rocks.[4] From this cave were obtained numerous bones of hyenas, associated with bones, more or less fractured, of a species of

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[1] See "Wonders of Geology," 6th edit. p. 176.

[2] A highly interesting account of the Ossiferous Caves of the Hartz and Franconia, by Sir Philip Grey Egerton, Bart., is published in "Geol. Proc." vol. ii. p. 94, for 1834.

[3] Dr. Buckland's celebrated work "Reliquiæ Diluvianæ," contains an admirable description of these caverns and their contents, with numerous plates. The student, in consulting this volume, must separate the *facts*, from the diluvial theory, which, at the period of its publication (1823), they were supposed by Dr. Buckland, and other eminent geologists, to confirm. See "Wonders of Geology," 6th edit. p. 179.

[4] For a general description of the cave at Kirkdale, see "Wonders of Geology," p. 180; and for details, "Reliq. Diluv."

tiger, bear, wolf, fox, weasel, elephant, rhinoceros, hippopotamus, horse, deer, ox, hare, or rabbit, mouse, water-rat, and fragments of skeletons of ravens, pigeons, larks, and ducks. Many of the bones exhibited marks of having been gnawed and crushed by the teeth of some animals. From all the facts observed, and which are detailed by Dr. Buckland with his wonted graphic power, it is inferred that the cave was inhabited for a considerable period by Hyenas; that many of the remains found there were of species carried in and devoured by those animals, and that in some instances the hyenas preyed upon each other. The portions of bone referable to the elephant are supposed to prove that occasionally the large mammalia were also obtained for food; but it is probable that the smaller animals were either drifted in by currents of water, or fell into the chasm through fissures now closed up by stalactitical incrustations.

Kent's Cave near Torquay, Oreston Cave near Plymouth, and several other caves in Devonshire, have yielded great numbers of bones and teeth of Carnivora, and of Pachydermata.[1] Kent's Cavern, or Hole, has proved the most productive ossiferous cavern in England; its vicinity to Torquay rendering it easy of access, it has been thoroughly explored. An extensive collection of fossil bones was obtained from this cavern by the late Rev. J. MacEnery; comprising, in addition to the usual extinct Carnivora, skulls and teeth of a species of Badger (*Meles taxus*), Otter (*Lutra vulgaris*), Pole-cat (*Putorius vulgaris*), Stoat or Ermine (*P. erminius*). The choicest specimens in that collection were obtained for the British Museum, and are deposited in Room VI.

In the western district of the Mendip Hills, in Somersetshire, there are several ossiferous fissures and caves. The most interesting are those of Hutton, on the northern escarpment of Bleadon Hill; and of Banwell, lying about a mile to the east of Hutton. They contain remains of the two species of cavern bears, one (*Ursus spelæus*) of immense size and strength; and of a species of Tiger, Hyena, Wolf, Fox, Deer, Ox, and Elephant.[2]

From the caves at Hutton, the Rev. D. Williams obtained the milk-teeth and other remains of a calf-elephant, about

[1] "Reliquiæ Diluv." p. 67. [2] See "Wonders of Geology," p. 181.

two years old, and those of a young tiger, just shedding its milk-teeth; also the grinders of a young horse, that were casting their coronary surfaces, and remains of two species of hyena.

In the modern silt of our alluvial districts, the remains of carnivorous animals, formerly indigenous in this island, are occasionally met with; and the skeleton of the Brown Bear (a species which inhabited Scotland eight centuries ago), and of the Wolf, whose extinction is of a yet later date, have been discovered. The Woodwardian Museum at Cambridge contains an entire skull of the Brown Bear (*Ursus arctos*), found in the Manea Fen of Cambridgeshire; and in an ancient fresh-water deposit, near Bacton, in Norfolk, the right lower jaw of the *Ursus spelæus* has been discovered.

Thus the remains of fossil Carnivora discovered in England comprise several kinds of Bear, including the two species of the caverns of Germany (*U. priscus* and *U. spelæus*); and of Tiger, Hyena, Wolf, Fox, &c.

Cave of Gailenreuth.—For many centuries certain caves in Germany have been celebrated for their osseous remains, particularly those in Franconia. The most remarkable of these caverns is that of Gailenreuth, which lies to the north-west of the village of that name, on the left bank of the river Wiesent, on the confines of Bayreuth.[1] The entrance to this cave is in the face of a perpendicular rock, and leads to a series of chambers from fifteen to twenty feet high, and several hundred feet in extent, terminating in a deep chasm. The cave is quite dark; and the icicles and pillars of stalactite, reflected by the light of the torches, which it is necessary to use, present a highly picturesque effect. The floor is literally paved with bones and fossil teeth, and the pillars and corbels of stalactite also contain similar remains. The bones are generally scattered and broken, but not rolled; they are lighter and less solid than recent bones, and are often encrusted with stalactites. Three-fourths of the bones belong to two species of Bear (*Ursus*), the remainder to Hyenas, Tigers, Wolves, Foxes, Gluttons, Weasels, and other small

[1] See "Medals of Creation," vol. ii. p. 869, for an interesting account of the present state of these caverns, by my friend, Major Willoughby Montague.

carnivora. The Hyena was allied to the spotted species of the Cape, but differed in the form of the teeth and skull.

Bones of the Elephant and Rhinoceros are said to have been discovered, together with those of existing animals, and fragments of sepulchral urns of high antiquity.[1]

Since the publication of the "*Ossemens Fossiles*," fossil remains of carnivora have been found in numerous localities of the Continent, and in our own island, and their anatomical characters and affinities examined and determined. In the "History of British Fossil Mammals," those of England are illustrated and described.

FOSSIL BEARS OF THE CAVERNS.—*Wall-case G.*—The collection contains a fine suite of crania, and jaws with teeth, and numerous detached teeth, and bones of other parts of the skeleton, of the two well-known species of cave-bears (*Ursus spelæus*, and *Ursus priscus*); and teeth and bones of hyenas, tigers, and other carnivora. As the bones are not arranged and labelled so as to admit of being identified without close inspection, our remarks must necessarily be limited to a few obvious specimens.

URSUS SPELÆUS, AND U. PRISCUS.—*Wall-case G: Lower compartment.*—The bones are principally referable to two extinct species of the genus *Ursus;* the largest has the skull more prominent in front than in any living species, and was named by M. Cuvier *Ursus spelæus*, or Cave-Bear; the other, which is of less size, and with a flattened forehead, is distinguished as *Ursus priscus*. A very extraordinary type of carnivora, which was named by Cuvier *Ursus cultridens*, from its enormous sabre-like canine teeth, is now placed in a distinct genus—*Machairodus*.

Ursus spelæus.—As the specific differences between the species of fossil cave-bears, of which there are some fine crania in the collection, chiefly relate to minute anatomical characters, which cannot be rendered intelligible without figures, it must suffice to mention in general terms, that the skull of the great Bear of the Caverns (*Ursus spelæus*) is much larger than that of any other species; the forehead is

[1] Dr. Buckland's "Reliquiæ Diluvianæ," previously referred to, contains a full account of the most remarkable ossiferous caverns and their contents.

more elevated, and forms a convex protuberance, and the profile of the head in front descends more suddenly to the nasal-bones than in other species; and some of the molar teeth are relatively larger and more complicated.

Some of the crania and bones from Gailenreuth indicate, according to Cuvier, a bear equal in magnitude to a large horse; the canine teeth are five inches long.

Ursus priscus.—There is a nearly perfect skull of an aged individual of this species from Gailenreuth in the Museum. The contour of the skull is less elevated than in the Brown Bear, and the forehead flattened, and the profile from the forehead to the nose has no depression.

The lower jaw resembles that of the recent Brown Bear (*Ursus arctos*), and is distinguished from that of *Ursus spelæus* by a small persistent premolar tooth in front of the antepenultimate molar, while the much greater relative space between the last-named tooth and the canine, separates the *Ursus priscus* from the existing Brown Bear.[1] The eminent zoologist, Mr. Waterhouse, under whose care this department of the Museum is placed, will, I doubt not, so soon as his multifarious duties permit, arrange and label this fine collection, so as to be intelligible and instructive to the casual visitors.

Machairodus (*Ursus cultridens of Cuvier*).—*Wall-case G: Uppermost Shelf.*—The upper canines of the animals of this genus, so closely resemble in their sabre-like form and serrated edges the teeth of the Megalosaurus (*ante*, p. 329), that when, in 1825, I received a cast of one from Baron Cuvier, I could scarcely persuade myself it did not belong to a species of that colossal reptile.

The teeth were first discovered in the Val d'Arno, associated with bones of bears, and M. Cuvier described them under the provisional name of *Ursus cultridens.* Specimens of large falciform canines, collected by the late Rev. J. MacEnery, in Kent's Cavern, were recognised by Dr. Buckland as belonging to the same genus of carnivora; and subsequently, a skull with teeth, but specifically distinct, was discovered in Auvergne, by M. Bravard; and other specimens were found by M. Kaup, at Epplesheim, near Darmstadt. M. Bravard described his specimen under the name of *Felis megantereon:*

[1] See Professor Owen's "Hist. Brit. Fos. Mam." p. 82.

M. Kaup proposed that of *Machairodus* for this new subgenus of Felidæ; a term which is now adopted by palæontologists.

A good model of the skull, with the jaws and teeth, is placed on the uppermost shelf of this cabinet. This cranium resembles that of the Panther, but the two enormous upper canines impart a most peculiar character to its physiognomy. The lower jaw has the symphysial portion of unusual depth, and there is a depression on each side to receive the upper canines when the mouth is closed. These teeth are of a falciform shape, thin and broad, with their edges finely serrated; they are relatively thinner, flatter, and wider, than the teeth of the Megalosaurus: the fang is contracted and solid.

MACHAIRODUS LATIDENS.—*Room VI.*—The teeth obtained from Kent's Cavern are placed, with other remains from the same ossiferous deposit, in Room VI. They are stated by Professor Owen to be specifically distinct from the *M. cultridens* of the Val d'Arno, and the *M. megantereon* of Auvergne. They are 6 inches long, and one inch two lines wide across the base of the crown; their greater width has suggested the name of *M. latidens;* they are figured and described in "Hist. Brit. Foss. Mammalia," p. 180. The animal to which they belonged is supposed to have been as large as the Tiger, and "to judge by its instruments of destruction, of even greater ferocity."

Two species of this remarkable genus have been collected by Major Cautley and Dr. Falconer, from the tertiary deposits of the Sewalik Hills.

I must not dwell longer on the specimens in this Case, except to notice the smallest, but most interesting, of the fossil remains it contains, namely, the lower jaw of a Marsupial Mammalian from the Oolite of Stonesfield.

CHAPTER IV.

PART V.

FOSSIL MAMMALIA OF STONESFIELD.

THE STONESFIELD OOLITE—FOSSIL MAMMALIA OF STONESFIELD—PHASCOLOTHERIUM—AMPHITHERIUM — STRUCTURE AND AFFINITIES OF THE FOSSIL MAMMALIA OF STONESFIELD—GEOLOGICAL INFERENCES.

THE STONESFIELD OOLITE. — On the middle shelf of Wall-case *G*, containing the fossil remains of the Bears of the Caverns, described in the preceding pages, the visitor will observe, in a mahogany tray, the lower jaw of a very small quadruped, attached to a piece of limestone from Stonesfield, which was presented to the Museum some years since by the eminent naturalist, W. J. Broderip, Esq. F.R.S.

This little fossil is one of the most interesting in the whole Gallery, for it was the earliest proof obtained of the presence of warm-blooded animals during that period of the earth's physical history, the "Age of Reptiles," of which we have treated so fully in a former part of this volume; and, consequently, carries back the existence of the highest class of vertebrata, to a period of unfathomable antiquity. The circumstances under which this fossil was discovered, and on which its interest so much depends, require therefore particular notice, for Stonesfield is the only locality in which mammalian remains have been observed in deposits more ancient than the eocene.

Stonesfield, a small village near Woodstock, about twelve miles north-west of Oxford, has long been celebrated for the

fossils imbedded in its slaty limestones, as we had occasion to observe when describing the remains of the Megalosaurus, in the previous chapter. In crossing the country from Oxford to Stonesfield, the Oxford clay, so rich in Ammonites, Belemnites, &c. is first observed; this deposit is succeeded by the Cornbrash,[1] the uppermost stratum of the Great Oolite group, which is seen beneath the clay in several quarries on the road-side between Woodstock and Blenheim.

The village of Stonesfield is situated on the brow of a valley, both sides of which are deeply excavated by the shafts and galleries that have been constructed for the extraction of the laminated oolitic limestone, or slate, as it is locally termed. The beds that supply the stone are at a depth of about fifty feet below the summit, and are worked by shafts. The upper twenty-five feet consist of clays alternating with calcareous stone; the lower, of fine-grained oolitic limestone abounding in casts of marine shells, among which a small species of trigonia is conspicuous. The strata that are worked do not exceed six feet in thickness, and consist of rubbly stone, with sand imbedding concretional masses of laminated grit, which, by exposure to the frost, admits of easy separation into thin flakes or slabs, that were formerly in general use for paving and roofing; like the slaty limestones of the Weald of Sussex.[2]

The abundance of the remains of terrestrial plants, of reptiles, and of land insects, in the Stonesfield strata, associated with the usual marine shells, &c. of the Oolite, proves the fluvio-marine origin of these deposits: in other words, this assemblage of terrestrial and deep-sea exuviæ indicates that these strata were formed in the bed of an ocean, into which the remains of the animals and plants of the neighbouring lands were transported by currents; while the fresh-water shelly limestones of the Wealden, together with the absence of marine species, equally demonstrate the fluviatile origin of that formation. Referring the reader to the "Wonders of Geology"[3] for a full consideration of the interesting questions

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[1] See Table of Formations, *ante*, p. 5.

[2] See "Wonders of Geology," p. 508, for an abstract of Dr. Fitton's account of the Stonesfield slate.

[3] Sixth Edit. Section V. pp. 507—512.

connected with this subject, we proceed to the examination of the specimen before us.

Fossil Marsupial Animal of Stonesfield.—(*Phascolotherium.*[1])—*Wall-case G.*—The following is Mr. Broderip's account of the discovery of this fossil: "Some years have elapsed since an ancient stone-mason, living at Heddington, who used to collect for me, made his appearance at my rooms at Oxford, with two specimens of the lower jaws of mammiferous animals, imbedded in Stonesfield slate, fresh from the quarry. One of the jaws was purchased by my friend Professor Buckland, who exclaimed against my retaining both, and the other I lent him some time ago."[2] It is now in the British Museum.

The discovery of the remains of undoubted mammalia in the lower oolite of Stonesfield, was first made known by Dr. Buckland in his Memoir on the Megalosaurus, in 1823, in the following words: "The other animals that are found at Stonesfield are not less extraordinary. Among the most remarkable are two portions of the jaw of the Didelphys, or Opossum, being of the size of a small Kangaroo Rat, and belonging to a family which now chiefly exists in America, South Asia, and New Holland. I refer the fossil in question to this family on the authority of M. Cuvier, who has examined it; and without the highest sanction I should have hesitated to announce such a fact, as it forms a case hitherto unique in the annals of Geology, viz. that of the remains of a land quadruped being found in a formation subjacent to the chalk."[3]

In the course of the quarter of a century that has since elapsed, six specimens of one side of the lower jaw, belonging to three species of mammalia, have been obtained from Stonesfield; and what is most remarkable, no other recognisable parts of the skeleton have been discovered.

Structure and affinities of the fossil Mammalia.—

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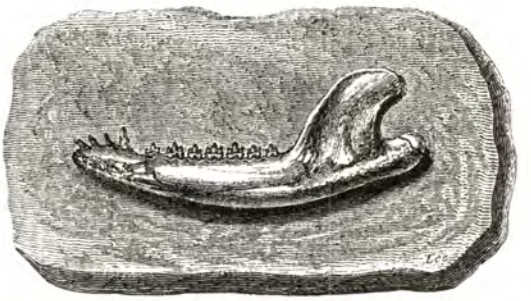
[1] *Phascolotherium;* signifying *Ancient phascolomys,* or pouch-animal; indicative of its affinity to the Wombat of New South Wales.

[2] "Observations on the Jaw of a fossil Mammiferous Animal found in the Stonesfield Slate." By J. W. Broderip, Esq. See "Zoological Journal," 1828, p. 1.

[3] "Geol. Trans." New Series, vol. i. p. 398.

These mammalian jaws belong to very small animals, and are referable to two genera. One of these, the *Amphitherium*, appears to have been an insectivorous mammal; it had thirty-two teeth (twelve molars, one canine, three incisors) in the lower jaw; its marsupial affinities are doubtful.[1]

The other genus, *Phascolotherium*, presents in its dental and maxillary organs the true characters of the Marsupialia. Baron Cuvier pointed out the extent and position of the inward inflection of the angular process of the lower jaw observable in the fossil, as indicating its marsupial affinities; for in the placental mammalia the same degree of incurvation is not present. This fossil mammalian has four true molar teeth, three false molars, one canine, and four incisors (three only remain in the specimen), in each ramus of the lower jaw; thus agreeing with the living species of Didelphys.



LIGN. 80. RIGHT SIDE OF THE LOWER JAW OF A MARSUPIAL MAMMALIAN; FROM STONESFIELD.

(Phascolotherium Bucklandi.)

(*Inner aspect; nat. size.*)

The condyle of this jaw presents the same form and degree of convexity as in the genera Didelphys and Dasyurus; the general shape and proportions of the coracoid process resemble those in the zoophagous marsupials; but in the depth and form of the entering notch between this process and the condyle, it corresponds most closely with the *Thylacinus*, a solitary genus of Australia (the Hyena of the colonists),

[1] "*Amphitherium Broderipii*" of Professor Owen. See "British Fossil Mammals," pp. 29—70, for figures and an elaborate account of the Stonesfield Mammalia.

whose term of existence seems fast waning to its close.[1] Professor Owen concludes with the following remark:—"Connecting the close resemblance which the molar teeth of the Phascolotherium bear to those of the Thylacine, with the similarities which have already been shown to exist in the several characteristic features of the ascending ramus of the jaw, I am of opinion that the marsupial extinct genus indicated by the Stonesfield fossil, was nearly allied to Thylacinus, and that its position in the marsupial series is between Thylacinus and Didelphys."[2]

Geological Inferences.—From what has been stated, it is evident that these mammalian remains from Stonesfield prove the existence at the commencement of the Oolitic period, of the two grand divisions of the class Mammalia, namely, the *marsupial*, and the *placental*. Commenting on this remarkable fact, Sir Charles Lyell observes, that "the singular accident of our having as yet found nothing but the half of the lower jaws of seven individuals, and no other bones of the skeleton, is alone sufficient to demonstrate the fragmentary manner in which the memorials of our ancient terrestrial fauna are handed down to us. We can scarcely avoid suspecting, that the two genera above described may have borne a like insignificant proportion to the entire assemblage of warm-blooded quadrupeds which flourished in the islands of the oolitic sea."[3]

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[1] "British Fossil Mammals," pp. 64, 65.

[2] Ibid. p. 67.

[3] "Manual of Elementary Geology," p. 270. This eminent philosopher, in his late Address on retiring from the chair of the Geological Society, again adverts to this important fact.—"Yet no small diligence has been used by collectors for more than a quarter of a century to obtain even the smallest isolated bones from these beds. I can only compare the capricious chance which has hitherto put us in exclusive possession of these seven mammalian jaws, with the equally strange accident recorded by Dr. Mantell in his career of discovery in the Wealden. He computed that in the course of 20 years he had found teeth and bones of the Iguanodon which must have belonged to no less than 70 distinct individuals, varying in age and magnitude from the reptile first burst from the egg, to one of which the femur measured 24 inches in circumference. Yet it was not until the relics of all these individuals were known, that a solitary example of part of a jaw-bone was obtained."—*Address delivered at the Anniversary Meeting of the Geological Society of London, Feb.* 21, 1851, *by Sir Charles Lyell, F.R.S.* p. 49.

CHAPTER IV.

PART VI.

FOSSIL SHELLS AND CORALS.

TERTIARY AND OOLITIC GASTEROPODOUS SHELLS—UNIVALVES FROM MINCHINHAMPTON—SHELLS IN SEPTARIUM—SHELLS FROM GRIGNON, HORDWELL, AND THE CRAG—CORALS AND OTHER ZOOPHYTES—NUMMULITES OF EGYPT.

FOSSIL SHELLS.—*Table-cases* 15 and 18.—The fossil shells deposited in these Table-cases are arranged zoologically; that is, as gasteropodous mollusca, without reference to their geological relations: thus the remains of extinct species and genera of molluscous animals that inhabited the seas of the oolitic period, and were contemporaries of the marine reptiles, the Ichthyosauri and Plesiosauri, which engaged our attention in the earlier pages of this chapter, are placed with the univalves that sported in the seas of the comparatively recent periods of the London Eocene, and the Crag.

The shells in Case 15, are chiefly from tertiary deposits; there is a fine suite from Hordwell,[1] and from Grignon. The fossils from the Great Oolite of Minchinhampton are particularly deserving attention, not only on account of the recently discovered species from that formation, but also for their remarkably perfect state; for they have been extracted from the rock with great skill.

SEPTARIUM WITH SHELLS.—*Table-case* 15.—In this Case there is a group of shells which affords an instructive illustration of the different aspects in which the same species may occur in a fossil state. The specimens to which I allude are

[1] See my "Geology of the Isle of Wight," p. 171.

on the right hand of the observer, and may readily be identified by the annexed *Lign.* 81.

The fossil, *Lign.* 81, fig. 2, is a polished slice of indurated argillaceous limestone, from the tertiary strata at

LIGN. 81. SEPTARIUM WITH TURRITELLÆ; FROM BRACKLESHAM, SUSSEX.
Fig. 1.—TURRITELLA IMBRICATA; the perfect shell.
2.—A polished slab of the Septarium.
3.—A cast of one of the shells, in calcareous spar.
(*nat. size.*)

Bracklesham Bay, Sussex, and is part of a septarium abounding in spiral univalves (*Turritellæ*). Fig. 1 represents a shell, extracted from soft clay; and fig. 3, a cast in calcareous spar, from the septarium. In the polished slab, fig. 2, sections of numerous shells are seen. The dark partitions, or septa, are veins of spar, which occupy interstices that

were formed in the clay-nodule by shrinking; and if the specimen be closely examined, the shells will be found split across and displaced by the fissures; thus presenting an interesting illustration of the *faults*, or dislocations of the strata, so familiar to the geological observer.

Fossil Shells.—*Table-case* 18.—These are chiefly from tertiary deposits; many are from the eocene strata of the Paris basin, at Grignon; these are recognisable by their whiteness; those from Hordwell by their dull leaden colour; while the shells from the Crag are more or less tinted with ochre. The specimens in both Cases are labelled, and named with great accuracy, by the eminent conchologist, Mr. S. P. Woodward, who has greatly increased the value and interest of this department of the Gallery of Organic Remains.

Corals and other zoophytes.—*Table-case* 17.—Until these fossils are marked and arranged, it is in vain to attempt a satisfactory description. I can merely mention that there are some fine specimens of corals from the Silurian rocks, and others from the Coral-rag of the Oolite formation.

Foraminifera.[1]—Of this interesting family of invertebrata, whose organization and zoological relations have but very recently been understood, there are specimens of some of the larger forms in the Case before us; viz. of *Nummulites* and *Orbitolites*.[2] Among the former, the visitor may observe a block of white limestone, composed of an aggregation of a species of *Nummulites*, of which there are detached specimens affixed to cards, and labelled; it is a fragment of the Great Pyramid of Egypt, that stupendous fabric being in a great measure built of nummulitic limestone.[3]

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[1] I would refer the reader for an account of the nature of the *Foraminifera*, to my "Pictorial Atlas of Organic Remains," p. 142, and p. 186; and Plates LXI. and LXII.

[2] The structure of these bodies has lately been ably elucidated by our eminent physiologist, Dr. W. B. Carpenter; "On the microscopic Structure of Nummulites, Orbitolites, and Orbitoides." Geol. Journal for 1850.

[3] This specimen was formerly in my collection. See "Wonders of Geology," vol. i. p. 248.

CHAPTER V.

PART I.

PLAN OF ROOM V.—SYNOPSIS OF CONTENTS—FOSSIL GANOID FISHES—SAUROID FISHES—CTENOID FISHES—CYCLOID FISHES—PLACOID FISHES—MALLOTUS VILLOSUS OF GREENLAND—FOSSIL RHINOCEROS—SIVATHERIUM—LEPIDOTUS—ASTEROLEPIS—ANTLERS OF THE IRISH ELK—FOSSIL PLACOID FISHES—ICHTHYODORULITES—TEETH OF SHARKS AND CESTRACIONS—BELEMNOTEUTHIS—BELEMNITES—SEPIADÆ—AMMONITES—NAUTILI—HAMITES—SCAPHITES—TURRILITES—ORTHOCERATITES—SKELETON OF THE IRISH ELK—FAMILIES OF FOSSIL FISHES IN THE MUSEUM.

THIS Room is chiefly devoted to the collection of *Ichthyolites*, or Fossil Fishes, which is very extensive, and admirably arranged and classified.

The specimens from the Devonian, Carboniferous, Oolitic, and Cretaceous formations, include a considerable number of species and genera; and among them are some splendid examples of Lepidoid and Ganoid fishes.

There are also many fine and rare Ichthyolites from the tertiary limestone of Monte Bolca, and from the slate of Glaris, and the keuper-schist of Mansfeld.

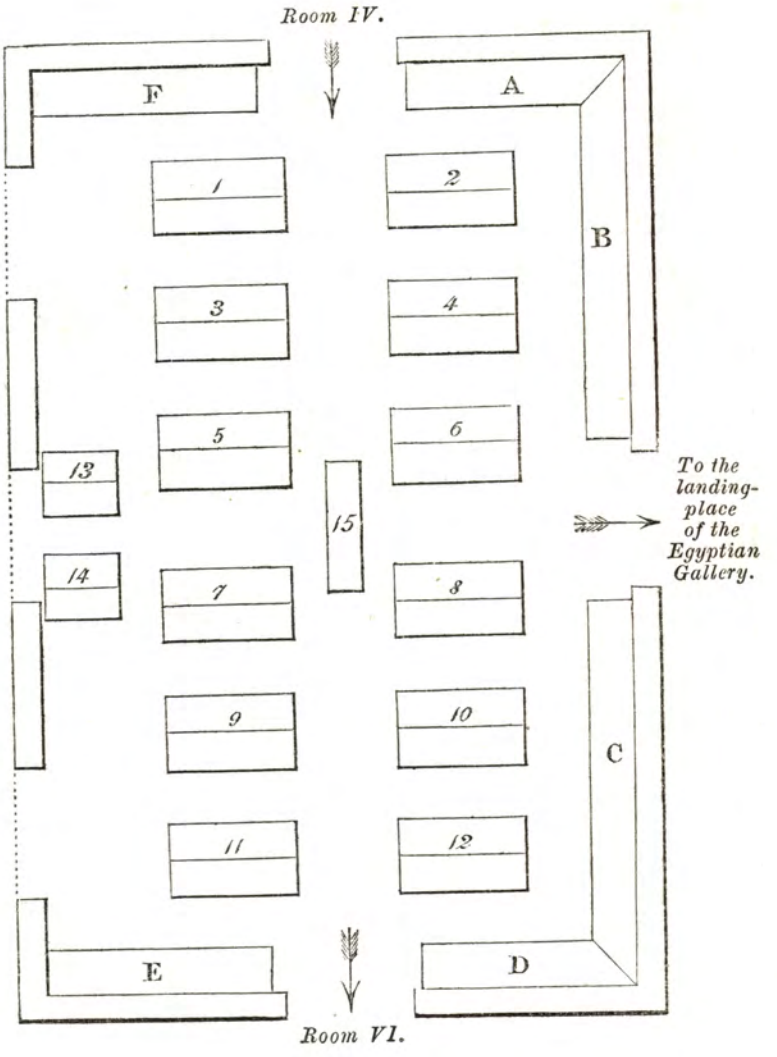
In the *Table-cases* on the left side of this apartment, are placed the fossil remains of the *Placoid* order, among which there are many choice specimens of the teeth and dorsal rays of *Cestracions* and *Chimæroids*.

The Wall-case *F*, contains crania, teeth, and bones, of the two extinct species of Rhinoceros, whose remains are commonly associated with those of the Elephant, Hippopotamus, &c. in the diluvial deposits of England and the Continent.

A part of the splendid collection of mammalian remains from the tertiary strata of the Sewalik Hills, is deposited in Wall-case *E*. The cranium, jaws, and teeth, of the *Sivatherium giganteum*, and of an extinct species of Camel, Giraffe, &c. are in this Cabinet.

A perfect skeleton of the gigantic IRISH ELK is a conspicuous object in the centre of this room; and there are antlers of the same noble animal on the Cases; one pair, originally in my collection, was purchased by me at the sale of the late Mr. Joshua Brooke, the eminent anatomist.

PLAN OF ROOM V.



A most interesting collection of fossil *Cephalopoda* occupies the Table-cases on the north side; it includes many rare and beautiful specimens of Belemnites, Belemnoteuthis, Ammonites, Nautili, &c.

It is impossible within the prescribed limits of this volume to do justice to the vast and important assemblage of fossil remains which this room contains, and I am compelled to restrict myself to a rapid survey of the most interesting objects. I subjoin for the aid of the scientific visitor a list of the principal genera of Ichthyolites of which there are specimens in the collection; as my descriptions must necessarily be of a very general nature.[1] The subjects will be treated of under the following heads: viz. I. Synoptical view of the Contents of Room V. II. Fossil Fishes of the Ganoid Order. III. Ctenoid, Cycloid, and Placoid Fishes. IV. Fossil Mammalia; Rhinoceros, Irish Elk, Sivatherium, &c. V. Fossil Cephalopoda.

ROOM V.

(*56 feet long.*)

SYNOPSIS OF CONTENTS.

ORGANIC REMAINS.

THE Wall-cases from *A* to *D*, inclusive, are filled with the rich and well-arranged collection of Fossil Fishes; M. Agassiz's classification is adopted.

"They are divided into four orders, viz. the *Placoids*, *Ganoids*, *Ctenoids* and *Cycloids*. The first of these orders comprises fishes mostly of considerable dimensions, and whose skeletons, by reason of their soft cartilaginous nature, are less enduring than those of the osseous fishes; their fossil remains, therefore, generally occur as detached scales, spines, teeth, palates, and fins, some of which, being small objects, are arranged in the Table-cases. The remaining three orders, demanding ample space, are placed in the upright Wall-cases. The *red* figures on the labels of the genera refer to the larger suspended boards bearing the names of the orders and families; but the names of the species are written on labels variously tinted, in accordance with the coloured tablets

[1] I would refer the reader wholly unacquainted with Fossil Ichthyology, to my "Medals of Creation," chap. xv.

within the cases, indicating the geological habitat of the respective specimens."—*Mr. König's Synopsis.*

The upright divisions of the glass-frames are numbered and labelled with the names of the tribes and families, as shown in p. 416.

A. [1 to 5.]. This Case is chiefly devoted to the *Ganoid* fishes. It contains beautiful specimens of the Devonian, or Old Red Sandstone genera (*Cephalaspides*), and of the *Lepidoids* of the Oolite, Wealden, &c.

B. [6 to 13] contains a rich assemblage of *Lepidoids, Sauroids,* and *Cœlacanthians.* Some splendid specimens of *Rhizodus, Holoptychius,* and *Macropoma,* are especially worthy of attention; the former are from the Carboniferous strata of Burdie House, the latter from the Chalk near Lewes; in the division [13], there is a large collection of *coprolites* of these fishes. Below the last-named specimens there are slabs of Old Red Sandstone, from Dura Den, in Fifeshire, with groups of fishes of the genus *Holoptychius.*

The specimen of *Holoptychius nobilissimus,* on the ledge below the Macropoma, is a splendid fossil from the Old Red Sandstone of Clashbinnie, near Perth, by the Rev. J. Noble. There is, likewise, a rare specimen of the same genus from Lethenbar, Scotland.

C. [15 to 22.] A beautiful collection of *Ganoid, Ctenoid,* and *Cycloid* fishes: many of these are from the Chalk of Sussex; others are from the tertiary strata of Monte Bolca, and among them are teeth, &c. of *Pycnodus, Spherodus,* and *Placodus,* from the Oolite. Fishes of the Perch Family; *Sparoids,* or Breams; *Cottoids,* or Bull-heads; *Goboids; Chætodons; Scomheroids,* &c.

D. [23 to 27] contains many fine examples of various species and genera of Cycloid fishes, comprising Esocids, Scomberoids, Clupeoids, Cyprinoids, &c. In this Case are some remarkable uncompressed fishes of the Salmon family, from the chalk of Lewes, in Sussex.

In the division at the end (27), is a specimen of the only known existing species of fish that has been found fossil, namely, the *Angmarset* (Mallotus villosus), which occurs in nodules of marl of recent formation, on the West Coast of Greenland.

E. This Case (on the right hand of the entrance to Room VI.) is filled with a very good collection of crania, teeth, and

bones, of two species of extinct rhinoceros (*R. tichorinus*, and *R. leptorhinus*), from the diluvial deposits of this country. There are also skulls of Rhinoceros from the frozen gravel of Siberia.

F. (On the right side of the entrance from Room IV.) There are several crania, and many teeth and bones of mammalia from the Sub-Himalayas, or Sewalik Hills. Among them are fine examples of jaws and teeth of an extinct species of Camel. But this Case contains a most interesting and unique specimen,—the skull of the *Sivatherium giganteum*. There is, likewise, the cast of the skull of another species of the same remarkable animal, the *Sivatherium Perimense*. On the top of this case there are casts of the entire series of bones of one of the limbs of the Sivatherium giganteum, from the originals in the museum of the East India Company.

On the top of the Wall-cases.

A. On the angle : a fine specimen of a very large river fish (*Lepidotus Mantelli*), from the Wealden of Sussex, presented by the Rev. John Gould.

B. Casts of the bones of the head of a gigantic species of *Asterolepis* (*A. Asmusii*), from the Devonian deposits of Riga; presented by Sir R. I. Murchison.

E. The skull and antlers of the Irish Elk.

F. There are three fine crania of bovine animals placed upright, and two or three imperfect specimens lying near them. The cranium on the left is from the Sewalik Hills ; the central specimen is also from India, but I could not ascertain the locality; it is said to have been presented by Major Rawlinson : both are undescribed species. The skull with horns of *Bos primigenius*, on the right, is from Scotland. There are several fossil crania of Bovidæ among the unarranged bones of mammalia in Case B. of Room II. ; but in the present state of the collection, it is useless to attempt to particularise them.

Table-cases.—As the Table-cases containing fossil fishes are on the south or left side of the room, and are numbered consecutively, it will be convenient to describe them in that order, beginning with *Table-case*, 2, of the annexed plan, (*ante*, p. 410.)

2. [1.] Order 1. Placoids.—*Ichthyodorulites.*—The osseous fin-rays, or spines, of various genera of cartilaginous fishes. They comprise a great many species from the secondary and

palæozoic formations. M. Agassiz has divided them into genera, according to their form and sculpturing.

This Case contains some beautiful *Ichthyodorulites* from the Chalk, Oolite, Lias, and Devonian strata, of the genera *Oracanthus, Ctenacanthus, Asteracanthus, Gyracanthus, Leptacanthus, Ptychacanthus,* &c.

4. [2.] Teeth of *Hybodus*, and maxillary bones of *Chimæroid* fishes: a fine series of the latter. Some of these beautiful specimens were collected by the late FREDERICK DIXON, ESQ. from the London Clay, at Bracklesham, Sussex,—namely, *Edaphodon, Ischyodus,* &c. which have been figured and described by Sir Philip Egerton.[1]

The other division of this Case is devoted to teeth of the *Squalidæ*, or Shark family; many are from the Sussex Chalk, and belong to the genera *Lamna, Otodus, Notidanus,* &c. There are also spines of a species of *Acanthias*, from the Lower Chalk, &c.

6. [3.] Vertebræ, teeth, and spines of Squalidæ from the Chalk, &c. Teeth and other remains of *Hybodus* from the Wealden, Oolite, and Lias.

8. [4.] Teeth of fishes allied to the *Cestracions*. The Cestracion is a genus of existing fishes inhabiting the seas of New Holland, and is commonly called the Port-Jackson Shark.

Teeth of species of *Ptychodus* (generally known as fossil palates, leeches, &c.), from the Chalk; and of *Acrodus, Orodus, Cochleodus, Psammodus, Strophodus, Ctenoptychius, &c.*

10. [5.] Teeth, and maxillary bones of fishes of the Ray family, chiefly from the London Clay. Many are from Bracklesham, and were collected by the late Mr. Dixon. They comprise specimens of *Myliobates* (Mul-rays), and *Ætobates*, (Eagle-rays), &c.

In the other compartment there are portions of the bony proboscis and teeth of the *Pristis* or Saw-fish, which are of extreme rarity in a fossil state. There are remains of two extinct species; *Pristis Hastingsiæ* and *P. distortus*, from Bracklesham, and Hordwell, &c.

In this Case there is a slab of limestone from Solenhofen, with numerous articulated rays of the dorsal fin of a large fish, presented by the late Marquis of Northampton.

[1] In the late Mr. Dixon's "Fossils from the Cretaceous and Tertiary Formations of Sussex," 1 vol. 4to. with numerous beautiful plates. 1851.

12. [6.] Unarranged specimens of fossil fishes.

The Table-cases on the opposite side of the room are devoted to Fossil *Cephalopoda*; as *Belemnites, Belemnoteuthis, Loligo, &c.*; and *Ammonites, Nautili, &c.*

Table-case 1.—This contains a fine suite of Belemnoteuthis, and other Sepiadæ, and Belemnites; chiefly from the Oxford Clay of Wiltshire. Among these fossils are examples of Belemnoteuthis, with the body, ink-bag, eyes, the arms, with the suckers, hooks, and other parts, beautifully displayed; and and of Belemnites with the phragmocones, and their elongated basal processes; these are especially worthy of close examination, for they incontrovertibly prove the correctness of the late Mr. Channing Pearce's opinion, that the soft parts of Cephalopoda found in the Oxford Clay, belong to a genus altogether distinct from the Belemnites with which they are associated.

3. A series of Belemnites; not yet arranged.

5. A miscellaneous collection of Ammonites; many of the specimens are of great beauty.

7. Ammonites. Many rare, and some unique specimens from the Chalk marl, collected by the author; as *Ammonites Woolgari, A. falcatus, A. navicularis, A. catinus, A. curvatus, A. cinctus.* (Figured in "Geology of Sussex," Pl. XXI., &c.)

9. This case likewise contains Ammonites of various genera and species.

11. It is intended to remove the fossil Insects and Crustaceans at present deposited in this Table-case, to Room VI. and substitute Ammonites.

13. This and the next table contain fossil shells of extinct genera of Cephalopodous mollusks. In the east compartment of the table, are *Hamites, Scaphites, Ancyloceras, Ptychoceras, Baculites,* and those enigmatical fossil bodies termed *Trigonellites,* or *Aptychus.* The other division is filled with *Nautili.* Among these are many *Rhyncholites,* or fossil beaks of Cephalopoda.

14. *Turrilites, Orthoceratites, Conularia,* and other allied forms. The Turrilites are remarkably fine; one of them is the largest discovered in England.[1]

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[1] See "Medals of Creation," p. 503.

15. Pedestal in the centre of the room. The skeleton of the extinct gigantic Elk of Ireland (*Cervus megaceros*). This specimen is seven feet high to the top of the forehead, and eight feet long; the distance from tip to tip of the antlers is nine feet.

*** To facilitate reference I subjoin a list of the families and tribes of Fossil Fishes as they are inscribed on the Wall-cases over the respective numbers.

List of Families and Tribes of Fossil Fishes in Room V.

The letters refer to the Plan, ante, p. 410: *the numbers to the divisions in the Cases.*

Ganoid Order.

A.

1. Cephalaspidians.
2. Lepidoids: homocercal and heterocercal.
3. Lepidoids (Tetragonolepis, Dapedius).
4. Acanthoidians. Lepidoids.
5. Dipterians. Lepidoids.

B.

6. Lepidoids.
7. Sauroids.
8, 9, 10. Sauroids.
11, 12. Cælacanths.
13. Cælacanths (Holoptychius—Macropoma).
14. Cælacanths (Holoptychius—Macropoma).

C.

15. Scleroderms. Gymnodons. Pycnodons. Siluroids.
16. Pycnodons.

Ctenoid Order.

17, 18. Percoids.
19. Sparoids. Mugiloids. Pleuronects.
20. Chætodons. Goboids. Aulostomes. Cottoids.

Cycloid Order.

21, 22. Scomberoids.
23. Labroids. Blennoids. Loplieoids. Xiphioids. Sphyrænoids. Scomberoids.

D.

24. Esocids. Scombero-esocids. Cyprinoids.
25. Cluperoids. Cyprinoids. Osmeroids.
26. Esocids. Halecoids.
27. Scopulines. Murœnoids.

CHAPTER V.

PART II.

FOSSIL FISHES OF THE GANOID ORDER.

ICHTHYOLITES, OR FOSSIL FISHES — AGASSIZ'S CLASSIFICATION — FINS OF FISHES—TEETH OF FISHES—TAILS OF FISHES—GANOID ORDER—CEPHALASPIDIANS—LEPIDOIDS—ACANTHODIANS—DIPTERIANS—SAUROIDS—CELACANTHS—SCLERODERMS—PYCNODONS.

ICHTHYOLITES, OR FOSSIL FISHES. — The fossil remains of FISHES are of great importance in a geological point of view, for they demonstrate the existence of highly organized beings in the most ancient fossiliferous strata, and the continuance of the same Class of vertebrata, variously modified, through the entire series of subsequent deposits to the present time. Each formation contains certain groups of fishes, distinguished by well-marked peculiarities of structure. Thus, according to the data at present obtained, all the osseous fishes that lived antecedently to the Chalk, belong to genera which have no representatives in the existing ichthyic faunas, and were covered by enamelled rhomboidal scales.

The state of preservation in which the fossil remains of fishes occur, has resulted from the relative delicacy or durability of the original structures, and on the chemical nature and mechanical conditions of the deposits in which they were imbedded. Thus the Ichthyolites of the most ancient sedimentary strata, the Silurian and Devonian, which are characterized by their dense integument and enamelled scales, often present the entire forms of the originals, and generally retain considerable portions of the scales connected, with the fins, and other appendages; while those of later formations, being chiefly species with delicate scales, more frequently

consist of the mineralized osseous skeleton. Deposits of mud or fine detritus, of whatever age, appear to have been most favourable for the preservation of the dermal integuments; hence we often find in the pulverulent clays and marls of the Tertiary strata, and in the Chalk of England and Westphalia, and in the fine lithographic stone of Solenhofen, fishes, perfect in form, and not only individuals, but groups, with the scales, fins, head, teeth, and even the capsule of the eye, in their original juxtaposition. In Chalk, some of the fishes occur with the body uncompressed, and as entire, as if the original had been surrounded by soft plaster of Paris while floating in the water. But in coarse limestones and conglomerates—in other words, in materials that have been subjected to the action of the waves and torrents—detached teeth, scales, bones, &c. constitute the principal vestiges of this class of beings.[1]

The cartilaginous or osseous nature of the skeleton, and the number and position of the fins, were the characters formerly employed in the classification of Fishes; but M. Agassiz, conceiving the structure of the skin to afford a natural index to the essential modifications of organization and functions, with great sagacity adopted an arrangement founded upon the form and structure of the scales, and divided the whole class into four orders, each distinguished by essential differences in the dermal (*skin*) system.

To the geologist this method has proved of inestimable value; for it is simple, easy of application, and, so far as our present knowledge extends, may be relied upon as affording accurate conclusions as to the nature and relations of the originals, to which a few detached fossil scales may have belonged. Another important aid has been derived from the microscopical examination of the structure of the teeth; a department of palæontological investigation, which is yet but partially explored.

The living species of Fishes exceed eight thousand, and those found in a fossil state, and determined by M. Agassiz, already amount to upwards of two thousand, while several hundreds are still undescribed, and the rapid progress of geological research is continually adding to the number. The

[1] See "Medals of Creation," chap. xv.

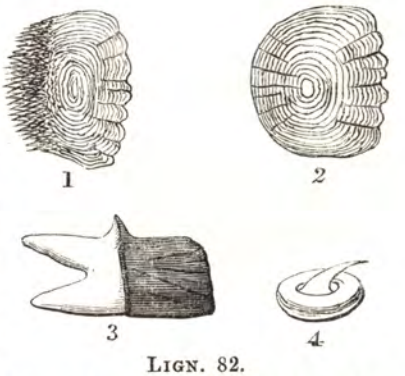
British species form a large proportion of the Ichthyolites illustrated and described by M. Agassiz; and fortunately, in our eminent Ichthyologist, *Sir Philip Grey Egerton, Bart.* we have an able and zealous cultivator of this branch of Palæontology.[1]

AGASSIZ'S CLASSIFICATION OF FISHES.—The four orders into which the class PISCES is divided by M. Agassiz, are founded on the following characters :—

Order I. PLACOID (from πλὰξ, *a broad plate*).—The skin covered irregularly with enamelled plates, sometimes of a large size, but frequently in small points, as the shagreen on the dermal integument of the *Sharks*, and the tubercles of the *Rays*. *Lign.* 82, fig. 4, a dermal spine from the skin of a Ray.

Order II. GANOID (γάνος, *splendour*, from the brilliant surface of the enamel).—The scales are of an angular form, and composed of plates of horn or bone, covered with a thick layer of enamel, a structure which is identical with that of their teeth. The *Sturgeon* is a living example of this order. *Lign.* 82, fig. 3, is a fossil scale of a fish of this division, the Lepidotus.

Order III. CTENOID (κτεὶς, *a comb*).—The scales are formed of plates, which are toothed or pectinated on their posterior margin or edge, like a comb. As the plates are superimposed on each other, so that the lowermost always extend beyond the uppermost, their numerous sharp points or teeth render the scales very harsh to the touch. The *Perch* belongs to this order. *Lign.* 82, fig. 1, represents a fossil *ctenoid* scale.



LIGN. 82.

ILLUSTRATION OF THE SCALES IN THE FOUR ORDERS OF FISHES.

1. CTENOID. 2. CYCLOID. 3. GANOID. 4. PLACOID SPINE.

Order IV. CYCLOID (κύκλος, *a circle*).—The scales are composed of simple laminæ, or plates of bone or horn, without enamel, and have smooth borders; but their external surface is often ornamented with markings. The scales of the lateral line consist of funnels placed one within the other; the contracted part of which,

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[1] The splendid and most important work entitled "*Recherches sur les Poissons Fossiles, par* LOUIS AGASSIZ," stands pre-eminent in this department of science. It consists of five volumes, 4to. of letter-press, and five volumes folio, of coloured plates. It is the classical work in this branch of natural history, and must be consulted by every one interested in the subject.

I would refer the reader for a condensed view of Fossil Ichthyology to my "Medals of Creation," vol. ii. chap. xv.

applied against the disk of the scale, forms the tube through which the mucus flows. To this order belong the Mullet, Salmon, and Carp. *Lign.* 82, fig. 2, is the scale of a fossil *Cycloid* fish.

FINS OF FISHES. — As the progression of fishes through the water is principally effected by the action of the tail, they have no limbs properly so called. The instruments for balancing the body, and for assisting progression, are the fins, which are composed of numerous rays that support a membranous expansion; and the number and situation of the fins present various modifications in the different orders and genera.

The spinous rays of the dorsal fins of the cartilaginous fishes, as the *Sharks* and *Rays*, generally occur detached from the body in a fossil state; they are abundant in some of the secondary deposits, and being often the only vestiges of extinct species and genera, possess great geological interest; they are termed *Ichthyodorulites* (*fossil dorsal-rays of fish*).

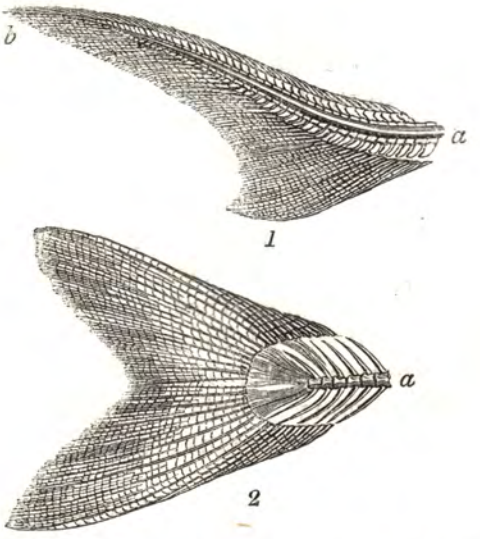
TEETH OF FISHES. — Of the durable parts of animals which occur in the mineral kingdom, the teeth of Fishes present the most numerous, varied, and striking modifications of form, structure, composition, mode of arrangement, and attachment; and yet these dental organs, separately considered, in many instances fail to afford characters by which the natural affinities of the original can be satisfactorily ascertained; and without the aid of other parts of the skeleton, it is often impossible to determine whether an unknown form of tooth belonged to an animal of the class of Fishes, or of Reptiles. Although the modifications of form are almost innumerable, they are referable to four principal types; namely, the conical, the flattened, the prismatic, and the cylindrical.[1]

STRUCTURE OF THE TAIL. — The tail, as we have previously mentioned, is the chief instrument of progressive motion in these animals; it assumes two principal modifications; and these characters the sagacity of M. Agassiz has invested with a high degree of palæontological interest.

In the greater number of the existing species, the vertebral column terminates in a triangular plate of bone, to which the

[1] See "Medals of Creation," pp. 597—601.

caudal fin is attached symmetrically; and its figure is either rounded, or divided into two equal lobes or branches; these tails are termed *homocercal*, i. e. even-tail, as is shown in *Lign.* 83, fig. 2.



LIGN. 83. ILLUSTRATION OF THE STRUCTURE OF THE TAIL IN FISHES.

1. *Heterocercal tail; a, b,* the vertebral column extending into the upper lobe; of a STURGEON.
2. *Homocercal tail;* of the ANGMARSET (*Mallotus villosus*) of Greenland. *a,* vertebral column.

In the second modification, the vertebral column, towards its extremity, diverges from a straight line, and rises up, and is prolonged into the upper lobe of the tail; the caudal fin appearing like a rudder, and the lower lobe being proportionably very feeble and small, as in the Shark and Dog-fish; (*Lign.* 83, fig. 1:) this form of tail is called *heterocercal*, i. e. unequal-tail. But few of the existing fishes have this condition of the caudal fin, while it is found in all the fossils that occur in the ancient secondary strata; namely, the Magnesian limestone, and antecedent deposits. The rounded, and equally-bilobed or homocercal tails, are seen in many of the beautiful fishes from the Chalk (*Lign.* 95); and the rudder-like, or heterocercal tail, is shown in many of the Ichthyolites from the Carboniferous strata (*Lign.* 85).

GANOID ORDER.—The fishes of this order are distinguished by their brilliant angular scales, composed of osseous or

corneous plates covered with a dense coat of enamel, which form a dermal integument of great strength and solidity. In many of the most ancient types, the body is literally enveloped in an osseous case; the bones of the cranium coalescing, and the scales of the thoracic, dorsal, and abdominal regions, blending as it were into a cuirass; hence the fishes of this order, which are among the most ancient known types of vertebrata, appearing in the Devonian or Old Red formation, afford the only absolute knowledge we possess of the earliest forms and structures of Ichthyic organization; for of the Placoids, which appear in a still earlier geological epoch,—namely, the Silurian,—owing to the cartilaginous and perishable nature of their skeletons, a few rays or spines, teeth, scutcheons, and shagreen skins, are the only vestiges that remain in a fossil state. Thus the minutely dentated fin-ray of the *Homocanthus*, of the Devonian formation, is the only fossil relic of that placoid; while in its contemporary ganoid fish, the *Osteolepis*, indications of the structure of the organs of smell, hearing, and vision, are manifest.

The Ganoid order comprises twelve families, examples of which are arranged in Wall-cases *A* and *B*, and are comprised in the subdivisions marked 1 to 16 in the compartments of the glass-cases; as enumerated in the list, *ante*, p. 416.

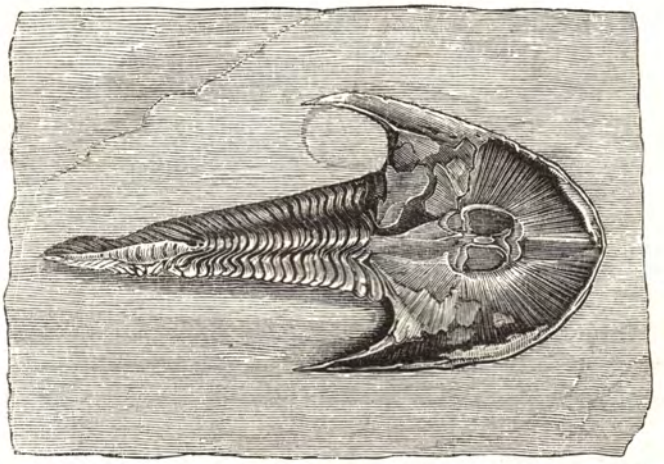
Cephalaspidians. — *Wall-case A.* [1.] — The Devonian Formation, (see *Geological Table, ante*, p. 5,) in which, but twenty-five years ago, a few single scales, discovered in Forfarshire by Dr. Fleming, were the only known traces of any vertebrated animals, has yielded upwards of sixty species belonging to nearly thirty genera, from British localities alone.

Of these the most characteristic are the *Cephalaspis*, *Pterichthys*, and *Coccosteus*, which form a group of extinct genera that has no representative either in the Silurian system below, or in the Carboniferous above; nor, except by distant and faint analogies with existing fishes, can these anomalous organisms be brought within the pale of zoological arrangement. These ichthyolites agree in one general character, that of being covered by relatively enormous osseous or horny plates, and scutcheons.[1] No vertebræ have been found, and it is supposed

[1] See "Medals of Creation," p. 645; "Wonders of Geology," p. 760.

that the spinal column was cartilaginous, as in the Sturgeon.

CEPHALASPIS LYELLII.—There are some very fine examples of this singular genus of small fishes, in the first division of



LIGN. 84. CEPHALASPIS LYELLII; FROM GLAMMIS, FORFARSHIRE. ($\frac{1}{4}$ *nat. size.*)

Case *A*, on the left of the entrance from Room IV., that were presented by the eminent geologist commemorated in the specific name; they will be easily recognised by the figure, *Lign.* 84.[1] The most striking feature in these Ichthyolites is the enormous scutcheon, or buckler, which forms the head, and is prolonged posteriorly into two lateral horns or points; this part so closely resembles the cephalic shield of certain trilobites, that the first specimens were supposed to be the remains of unknown crustaceans; the name *Cephalaspis* (*buckler-head*) is derived from this character. This remarkable appearance is occasioned by the intimate anchylosis of all the bones of the cranium. The body of these fishes is relatively smaller than the head, has but one dorsal fin, and terminates in a tail with a long pedicle, supporting a fin. There are two very small eyes placed towards the middle of the head. The body is covered with rhomboidal scales, and the head with

[1] The first fish of this genus was discovered by Mr. Hugh Miller, in whose charming little work, "New Walks in an Old Field," will be found a most graphic description of the Devonian Ichthyolites. I know not a more fascinating volume on any branch of Natural History.

discoidal ones, which are highly ornamented with radiated markings.

Pterichthys.—On the uppermost shelves of the compartment [2], there are several species of this genus, which, as its name implies, has two wing-like lateral appendages. These processes, like the spines of the Bull-head, (*Cottus Gobio,*) are weapons of defence; in some examples they are extended from the sides at right angles. The head and anterior part of the body are protected by large tuberculated scutcheons, and the back and abdomen by angular plates: the tail is long and angular, and supposed to have been the only organ of locomotion. There are two eyes in front of the lateral appendages. These Ichthyolites are only from two to ten inches in length.

Coccosteus (Berry-bone-fish).[1]—*Wall-case A.* [1.]—This is another allied genus, characterised by the tuberculated scales, and remarkable dental organs; neither eyes, nor pectoral fins or spines, have been discovered. There are some good specimens of these Ichthyolites on the uppermost shelf; their rich purple and reddish colour arises from an impregnation of phosphate of iron. There are three or four species, varying from a few inches to two feet in length. The remains of this genus are the most abundant of the ichthyic fossils in the Devonian deposits.

Pamphractus.—*Wall-case B.* [2.]—This is another genus of small fishes belonging to this singular family; it is distinguished by the distinct separation of the cephalic region from the thorax; it had a pair of long pointed pectoral fins. The specimen is from Dura Den, in Fifeshire.

Lepidoids.—This family of ganoid fishes is extinct, but existed in great force during the secondary epochs. It comprises sixteen or eighteen genera, which are divided into two tribes according to the structure of the caudal fin; of the *homocercals* (see *ante,* p. 421), of which there are twelve genera; the most striking specimens in the collection belong to Semionotus, Tetragonolepis, Dapedius, and Lepidotus. The *heterocercals* amount but to six or seven genera; among

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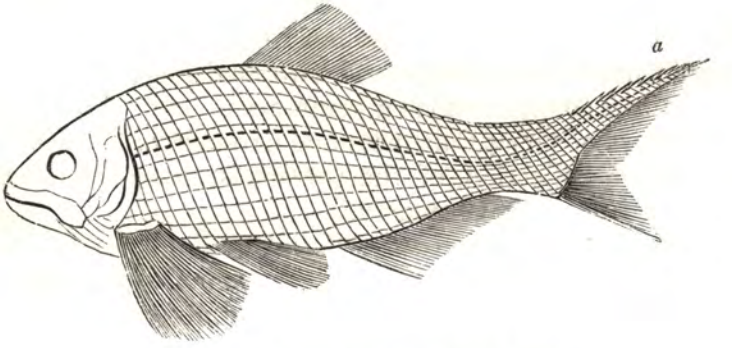
[1] Mr. Hugh Miller's works should be consulted for details of structure. The cranial bucklers of these Devonian Ichthyolites are admirably elucidated in the last work of this powerful writer and able observer. See "Footsteps of the Creator," pp. 51—78.

these are included the small Amblypterus, Palæoniscus, and Platysomus, of the carboniferous and triassic formations.

In the Lepidoids the importance of the character of the tail is strikingly manifest; for M. Agassiz has shown that all the *heterocercal* lepidoids, with but one exception, belong to the strata antecedent to the Lias; while the *homocercals* first appear in that formation, and continue to the tertiary deposits, in which the entire family disappears.

The Lepidoids have an osseous skeleton, and are armed with angular rhomboidal scales, parallel with the body. In some species, the dental apparatus consists of rows of broad teeth, in others of obtuse round teeth. The tail is relatively feeble.



LIGN. 85. AMBLYPTERUS; OF THE COAL.
a. The heterocercal tail. ($\frac{1}{4}$ *nat. size.*)

Amblypterus.— Wall-case A.—This small fish, from the carboniferous shale, is an example of a characteristic heterocercal lepidoid of that formation, to which six or seven species belong. It is distinguished by the wide and many-rayed fins without marginal rays, and the short and thick tail.

Palæoniscus.—The fishes of this genus have a general resemblance to the Amblypterus, but differ in the relatively moderate size of the scales, and the numerous little rays on their margins. There are upwards of twenty-five species; sixteen of which belong to the Coal formation, and these have smooth scales, with the exception of four species that occur in the strata at Burdie House, in which the scales are striated and punctated, like the seven or eight species of the

Triassic formation. Of the latter, *P. Freieslebeni* is a beautiful and common ichthyolite. There are very rarely any remains of the vertebral column.[1]

Semionotus.—*Wall-case A.* [No. 2.]—On the middle ledge of this Case there is a slab of lias from Coburg, on which is a group of fourteen specimens of a small, elegant, homocercal lepidoid fish, with a forked tail, (*S. Bergeri,*) belonging to this genus.

Osteolepis.—There are on the upper shelves of this Case (2), many examples of two other heterocercal families; 1. The *Acanthodians,* that were inhabitants of the Devonian and Carboniferous seas, and are characterised by their almost microscopic scales; of these the *Diplacanthus* (*double-spine*) is a well-known genus of Cromarty and Caithness. 2. The *Dipterians* have scales like the lepidoids, but differ from that family in having two dorsal and two anal fins; of this tribe, the *Osteolepis* (bony-scale) is a genus peculiar to the Old Red; three species occur at Caithness and Cromarty; there is a fine series in the collection, of the *Osteolepis macrolepidotus,* and *O. intermedius,* from Cromarty.[2]

Tetragonolepis; Dapedius.—*Wall-case A.* (2, 3.)—At Lyme Regis, and other productive localities of the Lias, large masses of angular enamelled scales, and occasionally entire specimens of the fishes to which they belonged, have for many years been collected. Sir H. De la Beche first scientifically investigated the structure of these Ichthyolites, and pointed out their characters and relations. The numerous examples subsequently brought to light establish, according to M. Agassiz, two genera of homocercal ganoids. The *Dapedius* (of which a restored figure is given in *Lign.* 86) is a wide, laterally compressed fish, with a rounded head, and fins of moderate size. The body rapidly contracts towards the pedicle of the tail, the fin of which is large, and symmetrically lobed. The mouth is furnished with several rows of small, conical teeth, crenated at their summits, and has brush-teeth on the palatine bones; the jaws are short. The scales are rhomboidal, highly polished, and united laterally by short processes, as in many other ganoids.

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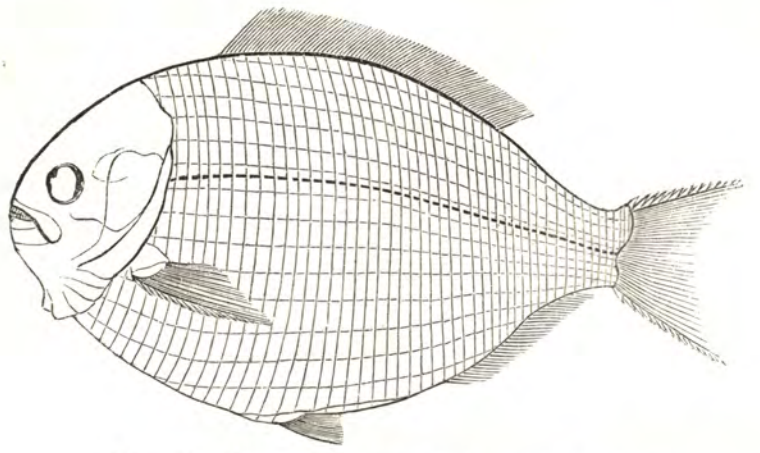
[1] See "Medals of Creation," 2d edit.

[2] See Mr. Miller's "Old Red Sandstone," Pl. IV. p. 72, for details.

In *Tetragonolepis* the teeth are pointed, and not crenated at the apex, as in Dapedius.[1]



LIGN. 86.—DAPEDIUS; OF THE LIAS.—($\frac{1}{6}$ *nat. size.*)

These common liassic Ichthyolites must be familiar to the intelligent visitor, as their form and structure are illustrated in Dr. Buckland's "Bridgewater Treatise." I would merely direct attention to the perfect state of some of the specimens in the Case before us.

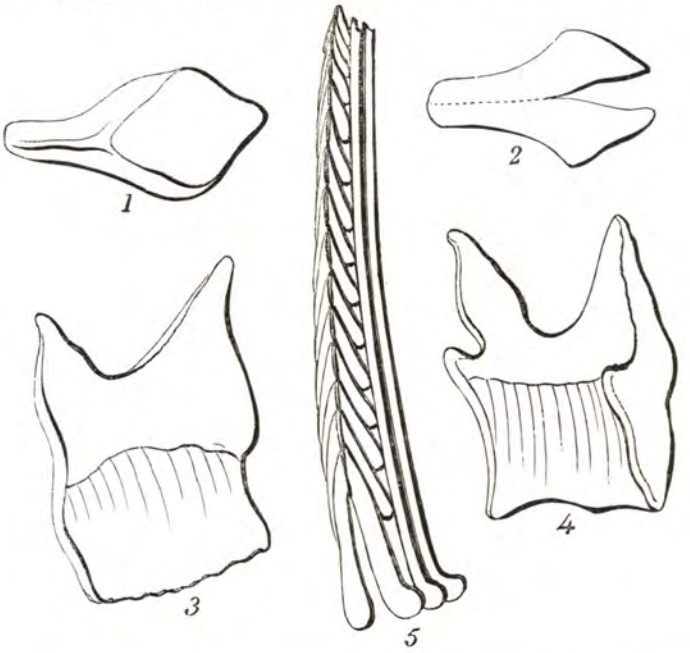
Lepidotus.—Wall-cases A. B. (4, 5.)—This genus of homocercal lepidoids comprises nearly thirty species, which were, for the most part, inhabitants of the liassic and oolitic seas. A few species existed during the deposition of the Cretaceous deposits; and one solitary type, the last of the race, according to our present knowledge, witnessed the dawn of the tertiary system. There are many beautiful specimens in the collection of the common Liassic, Oolitic, and Wealden species.

The separate scales and teeth of the lepidoti that frequented the estuaries and rivers of the Country of the Iguanodon, are abundant in the limestones of Swanage, and in the clays and calcareous grits and sandstones of Tilgate Forest.[2] In the angle of Cases *A* and *B*, there are several examples, more or less perfect, of *Lepidotus Fittoni* and *L. Mantelli*, formerly in my col-

[1] "Poissons Fossiles," tome ii. p. 181.

[2] They were first collected, figured, and described by me, in "Foss. Tilg. Forest," Pl. V. & X. See also "Wonders of Geology," p. 407; "Medals of Creation," p. 639, Pl. VI. fig. 10.

lection; and on the top of the Case a splendid specimen from Sussex, consisting of the anterior part of an enormous fish. The largest fragments of some of the Wealden Lepidoti indicate the total length of the fish to have been twelve or



LIGN. 87.—SCALES AND FIN-RAY OF LEPIDOTUS MANTELLI. TILGATE FOREST.

Fig. 1.—Scale, with a single process of attachment.
2.—One of the scales of the dorsal line.
3.—Scale (external surface), with a bifurcating process of attachment.
4.—Scale (viewed on the inner surface), showing the lateral processes.
5.—The front RAY of the dorsal fin, covered with two rows of enamelled scales, and two other rays behind it.
(*nat. size.*)

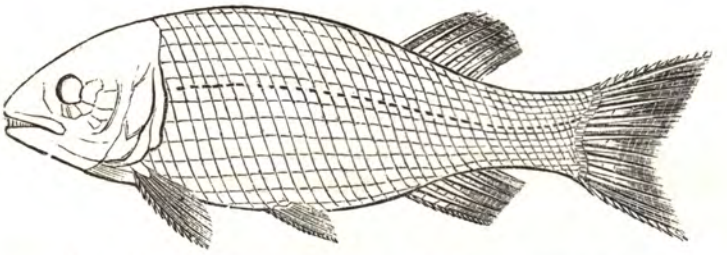
fourteen feet; and the width of the body from three to four feet.

These fishes resembled the Carps in their general outline but have no anatomical relations to that family. The jaws are short and rounded, and furnished with rows of obtuse hemispherical teeth; the head, and even face, were encased with osseous enamelled plates, which are often found separately imbedded in the rock; there are several large examples in the collection. The dorsal and pectoral fins are very strong, and consist of several bony rays. There is a double row of acuminated, enamelled scales, arranged ob-

liquely, on the anterior margin of the dorsal and anal fins, and on both margins of the caudal. (Part of the first ray of a dorsal fin, with scales, is represented *Lign.* 87.)

Lepidotus minor.—The smaller species is often found in the Purbeck limestone almost as entire as if recent, of which the beautiful Ichthyolite in Case *B* (No. 6), is an example.

At the bottom of this Case there is a specimen of *Lepidotus semiserratus* from the Lias of Whitby, remarkable for the per-



LIGN. 88.—LEPIDOTUS; OF THE WEALDEN. ($\frac{1}{6}$ *nat. size.*)

fect state of the head, which is uncompressed, and exhibits its normal form.

The habits of the Lepidoti, as indicated by the form and structure of the teeth, were those of fishes whose food consisted of crustaceans, shelly mollusca, &c.; for the dental organs are peculiarly adapted for the crushing and grinding of such substances; and the teeth of the adult fishes are generally worn down by use.

Pholidophorus.—This is a genus of small fishes allied to the Lepidotus, some species of which abound in the Lias and Oolite; their remains are commonly found associated with the skeletons of the enalosaurians, at Lyme Regis, Barrow-on-Soar, &c.; they have only brush-teeth. There are many specimens in this Case from Solenhofen.

SAUROIDS.—*Wall-case B.* (Nos. 7, 8, 9, 10.)—The fishes of the SAUROID (*lizard-like*) family were thus named by M. Agassiz, in consequence of certain peculiarities of organization which are found in no other animals of their class, but exist in reptiles.[1]

[1] "Recherches sur les Poissons Fossiles," par L. Agassiz, tome ii.

There are but two living genera, namely, the *Lepidosteus*, of which several species inhabit the rivers of America; and the *Polypterus*, that comprises two species, one inhabiting the Nile, and the other the rivers of Senegal. In these fishes the bones of the skull are closely connected by sutures; the teeth are large, conical, and longitudinally striated, as in the crocodile; the spinous processes are united to the bodies of the vertebræ by suture, as in most reptiles; and the ribs are articulated to the extremities of the transverse processes; the skeleton is osseous; the scales are flat, rhomboidal, and parallel to the body. Even in the soft parts many analogies are presented; thus the Lepidosteus has a glottis, as in the *Siren*, and a cellular air-bladder, with a tracheal vessel, resembling the lungs of an Ophidian (*serpent*). These fishes are the only living representatives of those voracious tribes of the ancient marine faunas, whose remains abound in the secondary formations.

The fossil remains of the fishes of this family have often been mistaken for those of reptiles, particularly the teeth, which from their large size, conical figure, enamelled and striated surface, and internal cavity, were supposed to belong to crocodiles.[1] These teeth consist of two kinds: the outer, or fish-like system, consisting of numerous small brush-teeth; and an inner row of large, pointed, conical, striated, enamelled teeth, placed at a distance from each other, as seen in the fine jaws of *Rhizodus* in No. 9, of Case B, (p. 433.)[2]

The sauroids, like the lepidoids, form two groups: 1, the homercercals contain fourteen or fifteen genera, among which are the *Leptolepis*, *Aspidorhynchus*, and *Belonostomus;* 2, the heterocercal tribe, which includes ten or twelve genera, and among them some of the largest and most remarkable ichthyolites of the Carboniferous system, viz. the *Rhizodus*, *Megalichthys*, and *Saurichthys*.

Leptolepis.—Wall-case B. (No. 7.)—The small fossil fishes, resembling a fry of Herrings, in the white lias of Solen-

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[1] An interesting paper, "On the Microscopic Structure of the Teeth of the *Lepidostei*, and their analogy with those of the *Labyrinthodonts*, with a Plate," by *Dr. Jeffries Wyman*, will be found in "Amer. Journ. of Science," October, 1843, p. 359.

[2] See "Medals of Creation," p. 651.

hofen, on the uppermost ledge, and from the Oxford Clay of Chippenham, immediately beneath, belong to this sauroid genus, which comprises sixteen or eighteen species, that are abundant in the upper divisions of the Oolite. The species from Chippenham is the *L. macropthalmus;* that from Solenhofen, *L. Knorrii.*

Cololites.—On the front of the same shelf are placed some small slabs of Solenhofen limestone, on which are convoluted worm-like bodies, formerly termed *lumbricarites,* from the supposition that they were petrified earth-worms. These curious fossils M. Agassiz has ascertained to be the intestines of fishes, and has, therefore, named them "*Cololites.*"[1]

Aspidorhynchus.—*Wall-case B.* (No. 10.)—In the lithographic stone of Solenhofen, specimens of sauroid fishes, closely related to *Lepidotus,* are discovered; they differ from the latter genus in the extreme shortness of the lower jaw, and the prolongation of the upper one into a long beak, bearing teeth even in that part which projects beyond the lower maxilla. The scales on the sides of the body are very high, and the tail is homocercal. There is a fine specimen (*Asp. acutirostris*) from Solenhofen in this Case, twenty-two inches in length. Near this specimen there is an ichthyolite of the same genus (*Asp. Comptoni*) from South America.

Belonostomus (*B. cinctus*).—*Wall-case B.* (No. 10.)—In 1820, I discovered the ichthyolites thus labelled, in the chalk, at Lewes; the great extent of the scales on the side of the body, in a vertical direction, was so remarkable, that until portions of the jaws, with teeth and other parts of the body, were obtained, the affinities of the original could not be determined. This fish, M. Agassiz estimated at three feet in length. A fragment, six inches long, of this species, is figured in Mr. Dixon's work, Pl. XXXV. fig. 3. I have recently discovered remains of this genus in the Wealden of the Isle of Wight, associated with teeth and scales of Lepidoti.

Pygopterus (*P. Humboldtii*).—*Wall-case B.* (No. 10.)—In this Case there is an ichthyolite from the copper-slate of

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[1] Figured in Dr. Buckland's "Bridgewater Essay," Pl. XV. See also "Medals of Creation," p. 657.

Mansfield, belonging to this genus of heterocercal sauroids, which is remarkably fine. It is a large species, with small scales, and the pectoral fin has a strong spine, or ray. Of *Acrolepis*, a nearly related genus, there is an example from the same locality at the bottom of this Case.[1]

A fine ichthyolite of the heterocercal sauroid genus, *Platygnathus*, from Dura Den, is placed immediately above the last-mentioned fossil.

Megalichthys; Rhizodus; Saurichthys.—Wall-case B. (No. 9.)—The specimens thus labelled are remains of three genera of heterocercal sauroid fishes, from the carboniferous deposits of Scotland, remarkable for the form and enormous size of their teeth and jaws, and the strong enamelled plates of the cranium. The conical, striated, gigantic teeth, some of which are five or six inches in length, so closely resemble those of crocodilian saurians, that they were generally ascribed to reptiles, till M. Agassiz pointed out the true characters of the originals. In *Saurichthys* the crown of the tooth is separated from the fang by a constriction, and the teeth are implanted in a furrow, or groove, as in the Ichthyosaurus. Remains of several species are found in the *Muschelkalk*.

The *Megalichthys*, a genus first made known by the elegant Memoir on the carboniferous deposits of Burdie House, near Edinburgh, by Dr. Hibbert,[2] in 1834, has enormous conical,

[1] WALL-CASE B.

(No. 10.)	(No. 11.)	(No. 12.)
Caturus.	Glyptolepis.	Phyllolepis: Scales only.
Saurichthys.	Macropoma.	Asterolepis. Russia.
Belonostomus. Chalk.	Glyptopomus, from the Devonian Sandstone of Scotland.	Bothriolepis.
Aspidorhynchus. Solenhofen.	Holoptychius, from Dura Den.	Rhinellus.
Platygnathus, from Dura Den.	Holoptychius: skull of undescribed species, from Australia.	Macropoma. (Numerous specimens, from Lewes.)
Acrolepis. Keuper schist.		Holoptychius Flemingii.
		Holoptychius Andersoni.

[2] In the "Trans. Royal Soc. Edinburgh," vol. xiii.

striated, hollow teeth, very closely resembling those of saurians; the head is encased in thick osseous plates, as in the recent *Polypterus;* the body is covered by large granulated scales. There are a fine lower jaw, teeth, and scales of *M. Hibberti* in this Case.

Rhizodus.—This fish, though clearly distinct from the Megalichthys, is often confounded with it by collectors. The genus was established from some detached teeth and jaws;[1] the scales are thinner, larger, and smoother than in Megalichthys, and their enamelled surface is finely punctated. The great strength of the cephalic plates, and of the jaws and teeth, of this powerful carnivorous fish, are well shown in the fossil remains from Burdie House, and Carluke, in Perthshire, which lie on the middle shelf of this compartment of Case *B.*

The conditions under which the remains of these enormous fishes are found imbedded at Burdie House, are highly interesting, for the limestone and marls in which they occur are at the bottom of the Coal formation, and abound in the foliage of ferns and other terrestrial plants, freshwater shells and crustaceans, and coprolites. These deposits must, therefore, have been formed in a lake, or estuary, frequented by predaceous sauroids; in like manner, as we have already shown, the bays and streams of the Country of the Iguanodon swarmed with the lepidoid fishes of the Wealden epoch.

Before proceeding to the next family of Ganoids, I would direct the palæontologist to the specimens of *Eugnathus* (*E. speciosus*), Wall-case *B* (9), and *Ptycholepis* (*P. Bollensis*), from the Lias of Wirtemberg; two genera of voracious sauroids, which are characterised by their unequal-lobed tail, large fins, and furrowed scales. Eleven species of Eugnathus have been discovered in the lias at Lyme Regis; only one species of Ptycholepis is known.

CELACANTHS (*hollow spine*).—This family of Ganoids is distinguished from the rest of the order by the tubular or hollow structure of the fin-rays and spinous processes;[2] the prolonga-

[1] See Dr. Buckland's "Bridgewater Essay," Pl. XXVII.

[2] Mr. Miller observes, "they were cartilaginous within, and covered externally by a thin osseous crust or shell, which alone survives."—"The Asterolepis," p. 37.

tion of the vertebral column between the principal lobes of the tail, and the articulation of the caudal rays by inter-apophyses. The fishes of this family are abundant in the Carboniferous and Devonian formations, and there are a few genera in the Triassic, Oolitic, and Cretaceous deposits: but no ichthyolites of this family have been observed in strata above the chalk. There are many splendid specimens of the principal types in Case *B* (Nos. 14, 15); especially of the Holoptychius from Scotland, and the Macropoma of the Chalk, from Lewes in Sussex.

HOLOPTYCHIUS.—*Wall-case B.* (No. 14.)—In this genus, the scales, which are very large, are deeply corrugated, and the bones of the head sculptured and granulated; the teeth are large, conical, and of great density; the ventral fins are nearer the tail than in the other ganoids; some of the spines are of great size. There are several large fishes of this genus from Scotland, in the lower compartment of this cabinet, so striking in their appearance, that they seldom fail to arrest the attention of the visitors. Of these, the *Holoptychius nobilissimus*, from the Old Red Sandstone at Clashbinnie, near Perth, (presented by the Rev. James Noble,) is the most conspicuous. This magnificent ichthyolite is figured in the splendid work of Sir Roderick Murchison, "The Silurian System," Pl. II.; it consists of the body and head, attached to the stone by the dorsal aspect. The body is depressed, and measures twenty-eight inches in length, and twelve in breadth. The head is short and obtuse; the lower jaw, the mouth, and the two branchial rays or plates are exposed. The scales are large, and strongly marked with undulating furrows; between the ventral fins and the head there are but fourteen scales. The tail is wanting.

Holoptychius Flemingii, and *H. Andersoni*, are two species of this genus which occur in the Devonian of Scotland; and there are two large blocks of fawn-coloured sandstone on which are seen lying in relief ten or twelve of these beautiful ichthyolites, whose jetty black finely contrasts with the hue of the surrounding stone. Many are from Dura Den, near Cupar, Fifeshire, the locality where the Rev. Dr. Fleming discovered the first recognised vestiges of this genus, in 1830.

Of the *Holoptychius Hibberti*, of the coal measures, whose

remains are commonly found associated with those of Megalicthys and Rhizodus, there are in this Case several specimens from Burdie House.

Asterolepis, (starry-scale.)—(A. Asmusii.)—Wall-case B.—On the outside of this Case on the top, there is a series of models of the cranial bones of an enormous fish, from the Old Red, near Riga; presented by Sir Roderick Murchison. This Russian ichthyolite is a species of *Asterolepis*, a genus that has recently been made the subject of an elaborate examination by Mr. Miller, who has published the results in a charming little volume, which I would earnestly recommend the reader to peruse.[1] These fishes attained a large size; probably from four or five to eighteen or twenty feet in length; for in the Russian model there is a hyoid plate two feet broad, and a maxillary bone twenty-eight inches long.

Macropoma Mantelli.[2]—*Wall-case B.* (Nos. 13, 14.)—The group of beautiful chalk fossils, thus labelled, comprises some of the first-fruits of my geological researches in the strata around my native town; several of them are unique, and others are the most instructive examples of this extraordinary type hitherto discovered. The general appearance of these fishes is well shown in the magnificent ichthyolite on the middle shelf (represented on a small scale in *Lign.* 89); in form the Macropoma resembled a large Carp; like the rest of the Celacanths, the rays and processes are hollow, and the cranium is covered with large granulated plates. The head is very large, being nearly equal to one-fourth the entire length of the body. The brush-teeth are very minute, giving a rasp-like surface to the borders of the jaws, and the conical teeth are small and pointed. The scales are enamelled on the exposed surface, which is covered with tubular spines. The opercula are remarkably long. The rays of the fins are large and rigid, especially those of the anterior dorsal, which are armed on each side with rows of sharp spines. The tail is

[1] "Footprints of the Creator, or the Asterolepis of Stromness." By Hugh Miller; p. 71. Ibid. p. 80.

[2] Described as *Amia? Lewesiensis.* "Fossils of the South Downs," 1822; tab. 37, 38. The large specimen figured in Pl. XVIII. I presented to Baron Cuvier, and it is now in the Museum of the Institute at Paris.—"Wonders of Geology," p. 348; "Medals of Creation," p. 655.

LIGN. 89.

MACROPOMA MANTELLI; FROM THE CHALK, LEWES.

DISCOVERED AND DEVELOPED BY THE AUTHOR IN 1823.

($\frac{1}{3}$ *nat. size.*)

large, rounded, and fan-shaped, with strong equal rays, supported by the inferior and superior spinous processes of the caudal vertebræ.

Air-bladder (or stomach ?) of the Macropoma.—In every example of this fossil fish that I have dissected, there lies within the body, generally nearest the upper or dorsal part of the cavity, a long, hollow, cylindrical substance, often seven inches in length, and $1\frac{1}{2}$ inch in diameter, covered with a thin, brittle, scaly integument, which readily separates into two or three laminæ. The anterior part of this organ, which lies close to the posterior margin of the opercular bone, is always imperfect, appearing as if torn or ruptured; the caudal extremity terminates in a *cul-de-sac*. From the situation and structure of this viscus, I supposed it to be an air-bladder, and described it as such in the "Fossils of the South Downs," (in 1822); but on M. Agassiz's visit to my Museum at Brighton, that eminent naturalist pronounced it to be the stomach. Recent microscopic investigations of the investing integument, have, however, tended to establish the correctness of my original interpretation of the nature of this remarkable body.[1]

The Macropoma when at maturity, was between two and three feet in length; its massive skeleton indicates a powerful frame, and its thick scales, strong fins, and sharp teeth, prove that it was a voracious fish, capable of overtaking and seizing live prey. I would especially direct attention to the various states of distension in which the air-bladder appears in the specimens here displayed.

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[1] My youngest son, Mr. Reginald Mantell, first detected the intimate structure of this organ, which has recently been admirably investigated by Prof. Williamson. See an able memoir *On the microscopic structure of the scales and dermal teeth of some ganoid and placoid fishes.* By W. C. Williamson, Esq. "Philos. Trans." 1849, p. 435. Pl. XLIII., figs. 27, 28, represent the microscopic structure of the scales of the Macropoma: and figs. 29, 30, of the air-bladder, described at pp. 462—465. Professor Williamson observes in relation to this fossil viscus—"I am disposed to believe it to have been an organ fulfilling the functions of an air-bladder. Its osseous structure would render it capable of resisting a considerable amount of pressure, and if its patulous extremity were closed up by an elastic valvular membranous appendage, the fish might have regulated its buoyancy by increasing or diminishing the compression of the gaseous contents of the bladder, and thus facilitate its movements in either shallow water or at great depths in the sea.

Coprolites of Macropoma. (No. 13.)—There is a large number of coprolites in this Case, which in all probability are referable to these fishes. They show that the spiral convolutions were fewer in the intestines of the Macropoma than in the Sharks.[1]

Lophiostomus Dixoni.—The chalk ichthyolite thus named (by Sir Philip Egerton) is from a quarry near Alfriston, in Sussex, and was collected by Captain Beckford, R.N. of Ryde, in whose choice cabinet of fossils I detected it as an unknown ganoid fish, and induced the liberal owner to add it to the National Collection. It will be figured and described in the "Memoirs of the Museum of Practical Geology." It is allied to the Macropoma, but differs in many essential characters: the large mouth garnished with numerous very small, slender, conical, fluted teeth, its granulated cranial plates, the form and structure of the lower jaw, the branchial plates, and the scales, which Professor Williamson informs me are altogether peculiar, render it a valuable addition to the Ichthyolites of the British Museum. The specific name was proposed by me, to commemorate the late F. Dixon, Esq. of Worthing.

Sclerderms.—This family of ganoids, to which the Diodons and Ostracions belong, besides certain peculiar modifications of the jaws, is distinguished by the dermal integuments, which consist of polygonal or rhomboidal plates, spread over the body like a tesselated cuirass; the skeleton is fibrous; the recent types are exclusively the inhabitants of the seas of hot climates.

Dercetis elongatus.[2]—*Wall-case C.* (No. 15, 16, *Middle shelves.*)—This is a very remarkable fossil fish from the chalk, near Lewes, which I discovered in 1818. The specimens commonly met with consist of fragments of the long subcylindrical body, covered with small scales, from a few inches to two feet in length, without any traces of the dermal scutcheons, fins, tail, or head; as in many examples in this Case, all of which are from my collection. The *Dercetis* had on each side of the body three rows of dermal scutcheons, like those of the Sturgeons; the intervals between them were

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[1] See "Medals of Creation," p. 650.

[2] "*Muræna?* Lewesiensis." "Fossils of the South Downs," tab. xxxiv. fig. 10, 11. See "Medals of Creation," p. 658.

covered with small scales. The cranium and elongated jaws, with teeth, are seen in an unique specimen in this Case; it is figured in "The Wonders of Geology," p. 349.

Blochius longirostris.—There is a fine example of this Monte Bolca ichthyolite, nineteen inches long, placed near the specimens of *Dercetis*. This genus resembles Belonostomus in its slender muzzle and general form; but it has brush-teeth and scutcheon-like scales, as in the Dercetis; the cranium with the beak measures nine inches in length.

GYMNODONS; SILUROIDS.—*Wall-case C.* (No. 15, 16.)—Of the former family, which closely resembles the *Diodons*, three species are found in the strata of Monte Bolca, of which there are specimens in the collection. The *Siluroids* are related to the *Silurus*, and a specimen from Bracklesham, formerly in Mr. Dixon's collection, is placed in this Case.

PYCNODONS.—*Wall-case C.* (No. 15, 16, *Lower shelves.*)—In this family of fishes the jaws are paved with rows of rounded, or elongated teeth; and many of the fossil species are only known by these organs. There are many beautiful fossils of this kind in the Case before us. I can only direct attention to several jaws, and many teeth of the genus *Pycnodus*, from the Wealden and Oolite; and to one extraordinarily perfect lower jaw of an allied genus *Gyrodus*, on the middle Shelf: it is labelled "*from Poulshot, near Devizes:*" every tooth is as perfect as when recent.

We now proceed to the examination of the Ichthyolites of the next order; the *Ctenoids*, occupying the compartments of Nos. 17 to 20 inclusive, in Wall-case *C;* the *Cycloids*, Cases *C* and *D*, and the *Placoids*, in the Table-cases Nos. 2, 4, 6, 8, 10, and 12 (see *ante*, p. 410), will also be included in the same division of the present Chapter.

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[1] See "Medals of Creation," p. 650.

CHAPTER V.

PART III.

FOSSIL FISHES OF THE CTENOID, CYCLOID, AND PLACOID ORDERS.

CTENOID ORDER;—PERCA—BERYX—SMERDIS—MONTE BOLCA ICHTHYOLITES. CYCLOID ORDER;—ENCHODUS—SAURODON—HYPSODON—CYPRINOIDS—ESOCIDS—HALICOIDS—OSMEROIDS—ACROGNATHUS—AULOLEPIS—MALLOTUS. PLACOID ORDER;—CHIMÆROIDS—SQUALIDÆ—HYBODONS—CESTRACIONS—PRISTIDES—RAYS—ICHTHYODORULITES—GEOLOGICAL DISTRIBUTION OF FOSSIL FISHES—GENERA OF ICHTHYOLITES IN THE BRITISH MUSEUM.

CTENOID ORDER.—The fishes of this Order, of which the Perch is the type, have imbricated laminated scales, the posterior margins of which are round and finely pectinated; *i. e.* divided into small teeth like a comb.

The *Ctenoidians* first appear in the cretaceous formation, those from the slate of Glaris being the most ancient known; certain species and genera are abundant in the White Chalk of the south-east of England, and of Germany; and may have been collected from strata of the same age in the Brazils. In the tertiary limestones of Monte Bolca there are numerous Ctenoid Ichthyolites.

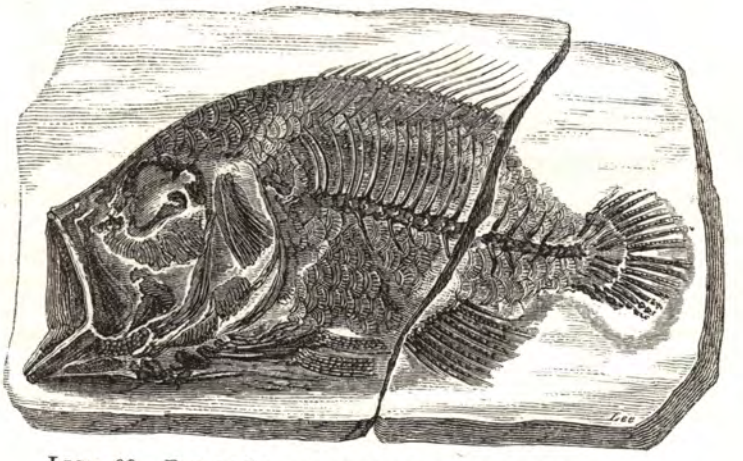
Almost all the fishes of this order in the Cretaceous formation are of extinct genera. One half of those from the eocene of Monte Bolca are also of lost generic types; whilst all the Ctenoids of the newer tertiary deposits belong to existing genera. The fossil Ctenoids in the British Museum comprise nearly thirty genera, belonging to eight families; a list of the whole is subjoined. I proceed to point out a few of the most interesting specimens.

PERCA.—*Wall-case C.* (No. 17.)—Of this typical genus of the Ctenoid order, there is a beautiful example of *Perca lepidota*, from the lacustrine deposits of Œningen (*ante*, p. 184).[1]

[1] These tables show the position of the principal Ichthyolites in Case *C.* No. 17, 18.

No. 17.	No. 18.
Perca (Œningen).	Cyclopoma (from Monte Bolca).
Beryx. | Gyrodus.	Pelatis. | Serranus.
Smerdis (Aix).	Beryx { Homonotus. / Stenostomos.
Rhacolepis (Brazils). | Enoplosus.	Myripristis.
Lates.	Labrax.

BERYX.—*Wall-case C.* (No. 17, 18.)—This fine series of Ichthyolites from the Chalk of Sussex, (formerly in my collection,) contains four species of a genus of the Perch family, named *Beryx*, of which there are two existing species in the Australian seas. The first that I succeeded in clearing from the chalk of Lewes, was the specimen of Beryx figured in my "Fossils of the South Downs," tab. 34, and which is in the Case before us; it was the first published representation of an Ichthyolite from the cretaceous formation of England; the fossil remains of fishes previously collected and described by authors, consisted of the teeth, bones, &c., but no one appears to have suspected that the scaly covering, with the fins, branchial arches, cranial bones, jaws, and teeth, were preserved, and could be displayed in their original position, by the skilful removal of the surrounding stone.



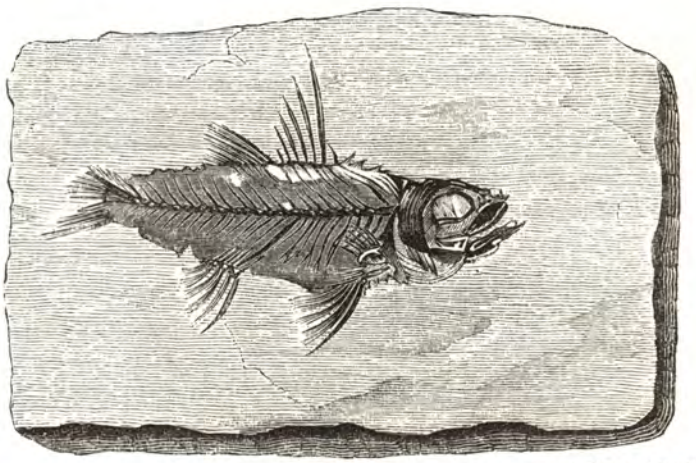
LIGN. 90. BERYX LEWESIENSIS, FROM THE CHALK, LEWES. ($\frac{1}{4}$ *nat. size.*)

The fishes of the genus Beryx are closely allied to the common Perches; they have one dorsal fin with several spinous rays in front of the soft rays, and the head is very large: the jaws are covered with a broad band of brush-teeth. The orbit is large, and often contains the capsule of the eye; the scales are relatively very large, the vertebræ large and short, with long apophyses, and the ribs short. The *Beryx Lewesiensis*, (Lign. 90,) is the most common of the Icthyolites of the white chalk; it is called the "Johnny-Dory" by the quarrymen of Sussex. Another and larger species (*B. superbus*), sometimes thirteen inches long, with very large and broad scales, occurs in the lower chalk at Lewes. There are two species from the chalk-marl;—*B. radians*, the scales of which are fringed with minute diverging spines;[1] and *B. microcephalus*, distinguished by its elongated form and small head. There are examples of both in the collection, from near Lewes,[2]

[1] See "Medals of Creation," p. 561, and "Wonders of Geology," pp. 350, 351.

[2] Of this rare Ichthyolite, I have lately been presented with a fine specimen from Clayton, Sussex, by my friend, Frederick Harford, Esq.

SMERDIS. (*S. minutus.*)—*Wall-case C.*—Certain strata of the eocene formation near Aix in Provence, abound in fossil shells, plants, insects, and fishes. The elegant little fish named Smerdis, a genus belonging to the tribe of Percoids, with two dorsal fins, and seven branchiostegous



LIGN. 91. SMERDIS MINUTUS; EOCENE STRATA, AIX, IN PROVENCE. (*nat. size.*)

rays, occurs in shoals, often grouped together in great numbers in the same slab of laminated limestone, and in every variety of position. There are numerous specimens in this Case, which were formerly in my collection.[1] The *Smerdis minutus* is from one to three inches long, and about the dimensions of a perch a year old.

MONTE BOLCA ICHTHYOLITES.—*Wall-case C.*—The Ichthyolites of Monte Bolca must be familiar to the reader, for in consequence of the abundance and beauty of these fossils, specimens are to be seen in almost every cabinet of organic remains. They are found in a tertiary cream-coloured fissile limestone, that generally splits in the direction in which the fishes are imbedded; hence the perfect animal, from the muzzle to the tail, with its fins expanded, is often obtained.[2] Referring to "The Wonders of Geology," p. 265, for an account of these deposits, I can only state, in brief, that there are in the collection under exami-

[1] The Chalk Ichthyolites in the British Museum, amounting to several hundred specimens, were, with but few exceptions, collected by me. The beautiful state of these fossils when in my possession, called forth the following remarks from M. Agassiz:—

"Tout le monde sait que le Musée de M. Mantell à Brighton, est une collection classique pour la Craie et la formation Veldienne. Les soins minutieux que M. Mantell a donnés depuis bien des années à ces fossiles, les ont rendus plus parfaits que tous ceux des autres musées; car souvent il est parvenu à les detacher entièrement de la roche dans laquelle ils se trouvaient, ou du moins à les produire en relief, en détachant toutes les matières solides qui recouvraient les parties les mieux conservées de l'animal."—*Recherches sur les Poissons Fossiles, par M. Louis Agassiz.*

[2] See "Wonders of Geology," p. 260.

nation, examples of the following genera, from this celebrated locality, viz.—*Lates, Cyclopoma, Enoplosus, Serranus, Pelates, Myripristis, &c.*

Of this Order, and from the same inexhaustible mine of Ichthyolites, are the fine specimens of *Callipteryx recticaudus*, and of the *Sparoids* (Breams), *Cottoids* (Bullheads), and *Goboids;* and that remarkable fish the *Semiophorus velifer*, in the Case before us.

Beneath the last-named Ichthyolite, there is a rare specimen of *Fistularia magnifica*, from the Engi slate of Glaris.

A beautiful example of *Mugil* (*M. princeps*), from Aix, in Provence, is placed in the upper part of the same case (No. 20); it was formerly in my collection; the muscles of the abdomen, fin-rays, &c. are finely preserved. Near these fishes there is a remarkable ichthyolite, *Calomopleurus cylindricus*, from the north of the Brazils, by Mr. Gardiner, from strata supposed to be of the cretaceous epoch.

Cycloid Order.—The essential character of the fishes of this Order are an osseous skeleton, and scales of a circular or cycloid form, with smooth margins, composed of plates of horn or bone, without enamel. To this Order the greater number of the fresh-water fishes belong; as the Pike, Carp, Trout, Salmon, &c. The palæontological history of this Order corresponds with that of the Ctenoids; in fact, the fishes of these two divisions, appear to constitute but one natural group.

There are no known cycloid fishes in strata below the Cretaceous formation; and those which occur in the Chalk belong to extinct genera. In the ancient tertiary the cycloids abound. Monte Bolca has yielded some genera and many species, hitherto unknown elsewhere. The collection contains a great many beautiful examples of the various generic types; these are enumerated in the general list, and the position in the cabinets of the most important fossils is indicated by the table at the bottom of the page.[1]

Enchodus.—*Wall-case C.* (No. 21.)—The upper and lower jaws, with long, pointed, conical teeth, of a fish of the scomberoid or mackerel family, in high relief from the blocks of chalk to which they are attached, are placed on the middle shelf of this Case. These teeth are remarkably well developed; they are rounded on the inner aspect and compressed externally; the two anterior ones of the lower jaw are very

[1] WALL-CASE C.

Upright Division, No. 20. Ctenoids.	*No. 23. Cycloids.*	*No. 24. Cycloids.*
Calomopleurus.	Tetrapturus.	Sphenolepis.
Mugil.	Cælorhyncus.	Istieus.
Platax.	Cladocyclus.	Hypsodon. (Three specimens belong to the same individual.)
Ephippus Bucklandi. | Naseus.	Sphyræna.	
Rhombus.	Sphyrænodus.	Leuciscus of Œningen.
Semiophorus.	Pachyrhizodus.	Acanthopsis.
Fistularia.	Saurodon.	Cobitis
Gobius | Cottus.	Saurocephalus.	Rhodeus.
Callipteryx recticaudus.	Ananchelus.	Lebias.
	Isurus | Archæus.	

large, and placed close to each other on each side the median line; the margins of the jaws are fringed with brush-teeth, and the jaws marked with granulated longitudinal ridges. These dental characters resemble those of two living genera of fishes, the *Thyrsites* and *Lepidopus*. The specimens are from Lewes, and were collected in 1820.[1]

Saurodon.—*Wall-case C.* (No. 23.)—There are several detached, lanceolate, laterally compressed teeth, and two or three specimens in which teeth of the same character are affixed to a portion of the jaw, in the front of this division of Case *C*. The latter instructive specimens were in the cabinet of the late Mr. Dixon; the former are from my collection.[2] These fossils belong to an extinct genus of fishes, which resembled the *Sphyræna*, or Barracuda Pike, in the form of the teeth and length of the jaws. The teeth on the palatine bones are barbed, and finely serrated.[3] The teeth of these fishes were first discovered in the Cretaceous Greensand of New Jersey, in the United States.[4]

Hypsodon (*H. Lewesiensis*).—*Wall-case C.* (No. 24.)[5]—The ichthyolites thus named are also from the Lewes chalk, and were among my earliest discoveries. They consist of the teeth and jaws, vertebræ, and some of the cranial bones, of a very large predaceous fish, whose long, conical, unequal teeth, remind us of the sauroids of the ganoid order. The three pieces of chalk containing portions of jaws with teeth, vertebræ, &c. are fragments of a large block, which was broken up by the quarrymen before the animal remains were observed. I collected the least injured pieces, and removed the chalk so as to expose the bones now apparent.[6] This genus is now referred to the family of *Scomberoesocids*, of Müller.

Of the freshwater fishes the *Cyprinoids* or *Carps*, there are fossil species of *Tinca* or Tench (*T. furcata*, and *T. leptosoma*) from Œningen; and of the *Leuciscus* or *Luce*, there is a very large fossil species (*L. Hartmanni*) from the tertiary strata of Steinheim, in Wirtemberg, and a small fish of the same genus (*L. papyraceus*), from the paper-coal of Bayreuth.

The fossil *Esocids* or *Pikes*, are in Cases Nos. 24 to 27, and comprise some beautiful examples of *Esox lepidotus* from Œningen. Of an extinct fresh-water genus named *Sphenolepis*, allied to the Pikes, there is a specimen of a very large species with robust vertebræ, and long striated scales, (*S. squammoseus*,) from Aix; and the *S. Cuvieri* from Montmartre.

The Ichthyolites of the Halecoids or Herring family, comprising the Clupeæ and Salmonidæ, are placed in Cases No. 25 and 26. Among the former is the *Clupea Scheuchzeri*, from the slate of Glaris.

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[1] Figured in "Fossils of the South Downs," under the name of *Esox Lewesiensis*, Tab. XLI. "Geology of the South-East of England," p. 140.

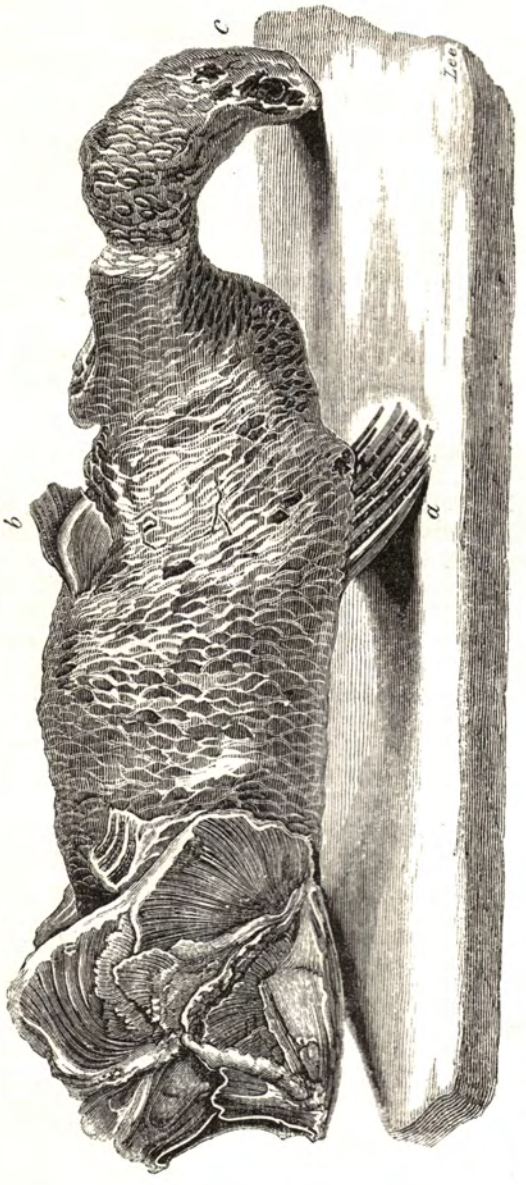
[2] Figured in "Fossils of the South Downs," Tab. XXXIII.

[3] See "Medals of Creation," p. 666, *Lign.* 136, fig. 3.

[4] See "Medals of Creation," p. 669.

[5] Tab. XLII. "Fossils of the South Downs," represents a vertebra, teeth, and bones of a fish of this genus.

[6] These specimens are figured in M. Agassiz's "Recherches sur les Poissons Fossiles."



Lign. 92. Osmeroides Mantelli; a Fish of the Salmon tribe, from the Lower Chalk, Lewes, 1821.

a, dorsal fin. *b*, ventrals. *c*, caudal fin.

($\frac{1}{2}$ *nat. size.*)

OSMEROIDES.—*Wall-case D.*[1] (No. 26).—The fossil fishes of the Salmon family, from the Sussex chalk, deposited in this Case, were the most beautiful ichthyolites in my collection; and though since the exposure of the specimens to the atmosphere of London they have lost much of their original brightness, and the pure white chalk appears like chalk-marl, yet the uncompressed state of many of these fishes, and the high relief in which they appear, render them objects of interest even to the uninstructed observer. These Ichthyolites are nearly related to the common *Smelt* (*Osmerus*); whence the name given to the genus, *Osmeroides*, by M. Agassiz. They were discovered, figured, and described, in my "Fossils of the South Downs," under the name of *Salmo Lewesiensis*. There are three species, two of which are well marked, viz. *O. Mantelli*, and *O. Lewesiensis*. The former has a short subcylindrical body, and seldom exceeds nine inches in length; the latter is of an elongated form, and sometimes attains a length of fourteen inches; the dorsal fin has more rays than in the former.

The first species is generally found with the head and body uncompressed; the most remarkable specimen hitherto discovered is on the front ledge of No. 26, and is figured in *Lign.* 92. This matchless ichthyolite is nine inches long, and the chalk has been cleared away so as to expose the entire body, lying six inches in relief above the block, to which it is attached by the dorsal aspect. The mouth of the fish is open, the opercula or gill-covers, and the branchial arches are expanded; the pectoral and ventral fins, and the dorsal fin, are in their natural position; the five rays of the dorsal are erect: there are but few traces of the caudal fin; in a specimen of *Osmeroides Lewesiensis*, in the same Case, a little adipose process, as in the recent Salmons, is situated between the dorsal fin and the tail.[2]

ACROGNATHUS (*A. boops*).—*Wall-case D.* (No. 25.)—This is a small unique ichthyolite which I discovered in a block of chalk from Southerham. It is an abdominal cycloid fish, with a large and flat head, and enormous orbits. The form of the fish, when recent, is shown in *Lign.* 93.

AULOLEPIS (*A. typus*).—Near the last described fossil there is placed another unique fish from the same locality, which is characterised by its slender muzzle, and conical teeth. The figure of the original is given in *Lign.* 94.

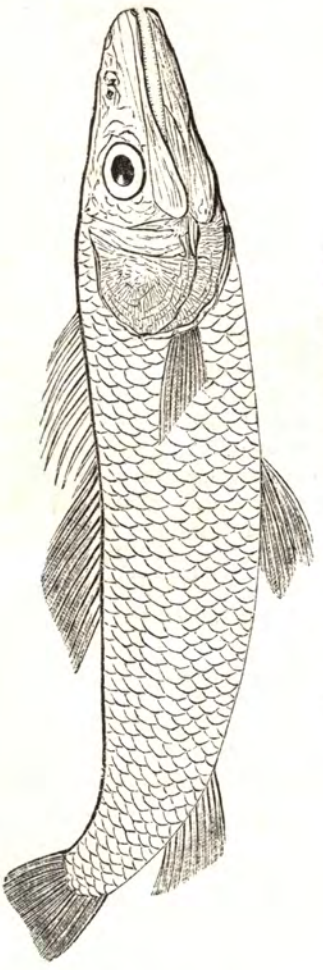
ICHTHYOLITES OF RECENT SPECIES; MALLOTUS.—*Wall-case D.* (No. 27.)—The eminent naturalist to whose labours the Ichthyologist is so greatly

[1] WALL-CASE D. CYCLOIDS.

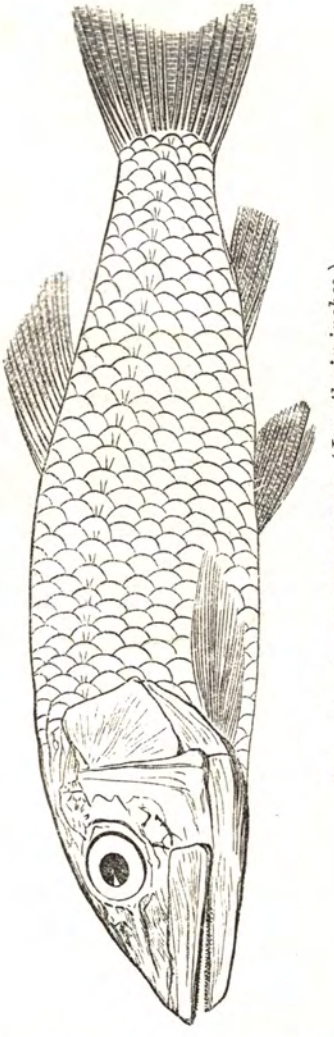
No. 25.	No. 26.	No. 27.
Esox.	Esox from Œningen.	Mallotus villosus; a recent ichthyolite, from Greenland.
Clupea.		
Acrognathus | Aulolepis.	Osmeroides (from Lewes.)	
Tinca.		Ampheristus toliapicus, (unique); from Sheppey.
Acanthopsis | Cobitis.	Small Jaw of Tomognathus.	
Rhodeus | Lebias.	Anguilla.	

[2] "Medals of Creation," pp. 594, 604.

indebted, affirms that of the many hundred fossil specimens submitted to his examination, only one can be identified with any living fish. The ichthyolites which form this remarkable exception are found in nodules of indurated clay, at the Sukkertop, on the West Coast of Greenland, and are identical with the living *Mallotus villosus*, or Angmarset, a



LIGN. 93.—ACROGNATHUS BOOPS. (*nat. size.*)



LIGN. 94.—AULOLEPIS TYPUS. (*Length six inches.*)

UNIQUE ICHTHYOLITES, FROM THE CHALK. LEWES. (*Discovered by the Author.*)

small fish allied to the Smelts, of which there is but one species, an inhabitant of the northern seas. These fossils are supposed to be of very recent formation; there is a specimen in the last division of Case *D*.[1]

[1] See "Recherches sur les Poissons Fossiles," tome v. Pl. LX. for figures of the skeleton of the recent Mallotus, and the fossil remains.

PLACOID ORDER.—In the placoid fishes the skeleton is cartilaginous, the gills are fixed, the skin is not covered with scales as in the other three orders, but either studded with bony tubercles or scutcheons of enamelled bone, or protected by very small bristly plates, constituting a tesselated integument, called shagreen. In consequence of the perishable nature of the skeleton, the teeth, spines, or fin-rays, tubercles and scutcheons, vertebræ, and in some rare instances the dermal shagreen, are the only parts preserved in a fossil state. The *Placoids* are the most ancient animals of the vertebrated classes hitherto discovered, for rays of a species of shark (*Onchus*) have been found in the Lower Silurian deposits; and they have continued through the entire series of formations, and abound in the present seas. But though the fishes of this order are the most universally distributed in time as well as in space, the relative numerical predominance of the several families varied greatly in different periods.

In *Table-Cases* 2, 4, 6, 8, 10, the collection of teeth, vertebræ, fin-rays, or Ichthyodorulites, &c. are arranged under the respective families to which they belong.

CHIMÆROIDS.—*Table-Case* 4.—A good collection of the maxillary organs, and the hard indivisible plates of dentine, composing the dental instruments of this curious tribe of the Shark family, belonging to four subgenera, is deposited in Table-Case 4. They are referable to *Ischyodus*, *Edaphodon*, *Psittacodon*, and *Ceratodus*. Among them are beautiful examples from the Eocene clay of Bracklesham, in Sussex, from Mr. Dixon's collection, and figured and described in his work by Sir Philip Egerton. There is one pair of mandibles in a block of chalk, remarkable for their prolongated and curved form, which led M. Agassiz to name the genus *Psittacodon*; the *Edaphodon*, of Sir P. Egerton.[1]

LIGN. 95.—MANDIBLE OF A CHIMÆROID FISH; EDAPHODON MANTELLI, FROM THE CHALK, LEWES. (½ *nat. size.*)

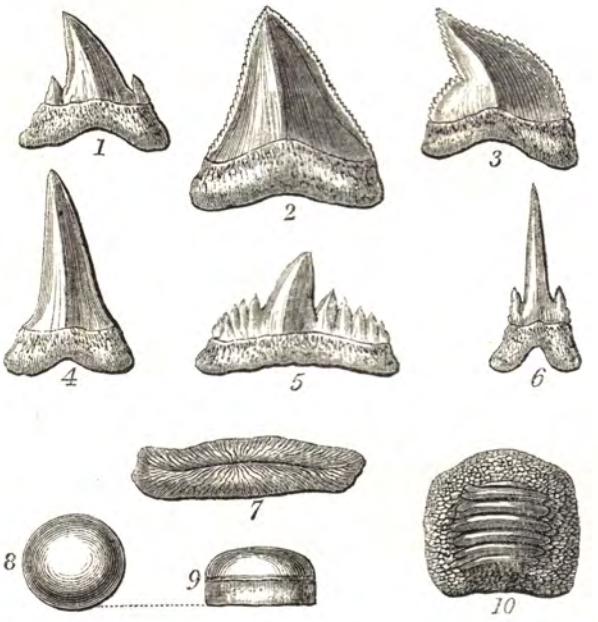
SQUALIDÆ, or SHARKS.—The fossil teeth of this universally distributed family of voracious fishes, are abundant in almost every secondary and tertiary deposit. Want of space compels me to refer to "The Medals of Creation," for a popular account of these fossil relics.[2] The collection is very rich in the usual types of the genera and subgenera. The sharp triangular teeth, with or without lateral denticles, and the cutting edges, either smooth or serrated, occur in profusion in many tertiary strata, and species of the same genera abound in the chalk. (*Lign.* 96.)

HYBODONS.—A family allied to the Sharks, but with conical and uncompressed teeth. These fishes had two dorsal fins, with anterior

[1] See "Geological Journal," May 1847.

[2] Chap XV. p. 611.

spines; the ichthyodorulites of this family are abundant in the Wealden, Oolite, &c.



LIGN. 96. FOSSIL TEETH OF FISHES; CHIEFLY OF THE SHARK FAMILY.

1. Otodus. 2. Carcharias. 3. Corax. 4. Oxyrhina.
5. Notidanus. 6. Lamna. 7. Acrodus.
8. Pycnodon; tooth of a ganoid fish; upper surface.
9. Lateral view. 10. Ptychodus.

CESTRACIONS.—Of this family a few teeth have been found in the Kentish Chalk, that belong to fishes of the existing genus *Cestracion*, or Port Jackson Shark. A genus of this family, named *Ptychodus* (rugous-tooth,) must have swarmed in the cretaceous ocean, for its large, quadrate, channelled molars, are found in every quarry of the White-

LIGN. 97. TEETH OF HYBODUS.

Chalk (*Lign.* 96, 10); there are groups of from ten to fifty on blocks of chalk in the Table-cases.

Of the PRISTIDES, or Saw-fishes, there are a few teeth, and portions of the beak, of two species, from the Eocene of Bracklesham.

FOSSIL RAYS.—Instead of pointed teeth, the masticatory organs of the fishes of this family are wide, flat, dental plates, composed of distinct

pieces in close juxtaposition and united by fine sutures. There are fifteen fossil species of the *Myliobatis* (Eagle-ray), in some of which the dental plates are of great size, as shown by specimens in the Table-case under review. There are likewise some fine examples of the allied genus, *Ætobatis*, from Bracklesham.

Ichthyodorulites, or *Fossil Dorsal-fin-spines.—Table-cases*, 2, 4, 6.—The fossils thus named are the rays or spines of the dorsal fins of cartilaginous fishes; of these, there is an extensive series in the collection, as specified in the *List of Genera*. I would direct attention to some beautiful specimens in the *Table-case* 2, and especially to the large spine of *Ptychodus spectabilis* in Chalk, formerly in my collection, and one of the most interesting fossils of this kind hitherto discovered.

Geological Distribution of Fossil Fishes.—From the incidental notices of the geological habitats of the Ichthyolites described in the preceding pages, the intelligent reader cannot fail to perceive that the most recent deposits abound in forms allied to the existing genera and species, while the most ancient teem with unknown families, which are either utterly extinct, or of excessive rarity at the present time. M. Agassiz affirms that in a general sense we may conclude that the Ichthyolites of the Tertiary deposits approach in their character to the living genera, but all the species are extinct. That the newer Tertiary, as the Crag, contain genera common to tropical seas, as the large sharks (*Carcharias*), and eagle-rays (*Myliobates*), &c. In the Eocene, as the London and Paris basins, Monte Bolca, &c. *one*-third of the Ichthyolites belong to extinct genera. Of the Chalk fishes, *two*-thirds are of extinct genera, but related to those of the Tertiary formations. From the Oolite to the Lias, including the Wealden, the fishes constitute a natural group, but few species of which occur in the Chalk, and all the ganoid fishes are *homocercal;* below the Lias, a prodigious number of unknown genera and species appear, and these are almost all *heterocercal*.

Thus of the eight thousand living fishes known to naturalists, three-fourths belong to the Cycloid and Ctenoid orders, and of these no species occur below the Chalk; the other fourth is referable to the Placoids and Ganoids, of which there are comparatively but few existing species. Yet fishes of these two orders were almost the sole representatives of the Class *Pisces*, during the ancient secondary formations; for below the Lias, the predominant recent orders are altogether absent. Beneath the Coal true carnivorous fishes, with trenchant teeth, are almost unknown; omnivorous species, with either brush or obtusely conical teeth, and great sauroid fishes, are the prevailing representatives of the class. In fine, the Ichthyolites of the different formations constitute two grand groups, which have their boundary line at the base of the Cretaceous deposits. The first and most ancient comprises the Ganoids and Placoids; the second is more intimately related to existing types, and comprehends forms more diversified; these are principally Ctenoids and Cycloids, with a small number of the two preceding orders, which insensibly disappear, and their few living analogues are very distinct from the ancient species.

Now, although deductions of this nature may require to be modified with the progress of knowledge, yet the generalizations thus obtained are founded on so great an accumulation of facts and observations, as to

render it improbable that they will be materially invalidated by future discoveries; for they accord remarkably with the results derived from the investigation of the fossil remains of the other Classes of animals. The most modern deposits contain the remains of animals allied to species of existing genera; the most ancient, of forms altogether extinct, or of excessive rarity in the recent faunas. The discovery of existing species, or genera, in the most ancient strata, would modify, but not destroy, the inferences deduced from the facts hitherto obtained; and every geologist is prepared to find that such may be the case.

Thus, of the sharks, with serrated triangular teeth, whose relics are so common in the Tertiary formations, and were formerly unknown in the ancient Secondary, one representative has been found in the Carboniferous system;[1] but, if teeth of this character should hereafter be discovered in other Secondary deposits, the great preponderance of this type in the Tertiary strata, and in the existing seas, would not be the less remarkable.

List of the Genera of Fossil Fishes, of which there are examples of one or more species in Room V. of the British Museum.

WALL-CASE A.—(1, to 5.)

Coccosteus. (C. decipiens, C. cuspidatus, from the Devonian of Cromarty; C. oblongus, from Lethenbar.)
Cephalaspis. (C. Lyellii, from the Devonian formation, Forfarshire.)
Gyrolepis. (G. Rankinii.)
Pholidophorus. (P. taxis.)
Amblypterus. (A. macropterus.)
Pamphractus. (P. hydrophilus.)
Diplacanthus. (D. striatus.)
Cheiracanthus. (C. microlepidotus.)
Pterichthys. (P. oblongus.)
Platysomus.
Cheirolepis. (C. Cummingiæ, from Devonian strata, Cromarty.)
Acanthodes. (A. Brownii.)
Osteolepis. (O. intermedius, Devonian, Cromarty.)
Dapedius. (D. politus, D. Colei, lias of Dorsetshire.)
Tetragonolepis. (T. speciosus, from the lias, Lyme Regis.)
Semionotus. (S. Bergeri, a group of several, in lias, Coburg.)
Palæoniscus. (Several from the Zechstein of Thuringia.)
Lepidotus. (L. Fittoni, L. Mantelli, Wealden of Tilgate Forest.)

WALL-CASE B.—(6, to 14.)

Dipterus. (D. macrolepidotus.)
Leptolepis. (Several species from the Oolite, Solenhofen.)
Sauropsis. (S. latus.)

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[1] *Carcharopsis prototypus.*

Megalichthys. (M. Hibbertii, carboniferous, Burdie House, near Edinburgh.)
Rhizodus. (R. Hibbertii.)
Pygopterus. (P. Humboldtii, copper slate of Mansfeld.)
Megalurus. (M. lepidotus.)
Eugnathus. (E. chirotes, lias of Wirtemberg.)
Thrissops. (T. formosus.)
Ptycholepis. (P. Bollensis, lias of Wirtemberg.)
Pachycormus. (P. gracilis.)
Caturus. (C. dubius, C. macrodus.)
Saurichthys. (S. apicalis.)
Acanthopleurus. (A. serratus.)
Aspidorhyncus. (A. acutirostris, very fine, from Monte Bolca.)
Platygnathus. (P. Jamesoni.)
Belonostomus. (B. cinctus, from the chalk near Lewes.)
Acrolepis. (A. asper, from the Keuper schist.)
Diplopterus. (No species labelled.)
Holoptychius. (H. Flemingii, H. nobilissimus, from Devonian sandstone, Clashbinnie, near Perth.)
Glyptolepis. (G. leptopterus.)
Asterolepis. (A. Asmusii, Devonian of Riga.)
Bothriolepis. (B. priscus.)
Rhinellus. (R. furcatus.)
Macropoma. (M. Mantelli, Chalk formation, Lewes, Sussex.)
Lophiostomus Dixoni. A new ganoid from the South Downs, (*ante*, p. 433.)
Phyllolepis. (P. tenuissimus.)

WALL-CASE C.—(15, to 23.)

Dercetis. (D. elongatus, from the chalk at Lewes.)
Blochius. (B. longirostris, Monte Bolca; a very fine example.)
Acanthopleurus. (A. serratus, chalk formation, slate of Glaris.)
Pimelodus. (From the Sewalik Hills.)
Gyrodus. (S. angustus.)
Pycnodus. (P. gigas, from the Upper Oolite; P. Mantelli, Wealden.)
Platysomus. (P. gibbosus.)
Placodus. (P. gigas, from the Muschelkalk of Franconia.)
Acrotemnus. (A. faba, Sussex chalk.)
Silurus. (S. Egertoni, eocene clay, Bracklesham, Sussex.)
Sphærodus. (S. gigas, from the Oolite.)
Phyllodus.
Microdon. (M. nuchatis, Lewes chalk; M. hexagonus, Monte Bolca.)
Perca. (P. lepidota, from Œningen; very fine.)
Cyclopoma. (C. gigas, Monte Bolca.)
Pelates. (P. quindecimalis, Monte Bolca.)
Serranus. (S. occipitalis.)
Beryx. (B. Lewesiensis, *Mantell*, B. ornatus, *Agassiz*, Lewes chalk, discovered in 1820.)
——— (B. radians, B. microcephalus, and B. superbus, from the Lewes chalk.)
Smerdis. (S. minutus, Eocene, Aix, Provence.)
Rhacolepis. (R. Brama, R. latus, from the chalk formation of Brazil.)

Lates. (L. notæus, L. gibbus.)
Enoplosus. (E. pygopterus, Monte Bolca.)
Myripristis. (M. leptacanthus, Monte Bolca.)
Labrax. (L. schizurus, on a small slab there are four perfect fishes. Monte Bolca.)
Homonotus. (H. dorsalis, Chalk.)
Stenostomus. (S. pulchellus, Sussex chalk.)

NOTE.—Under the PERCOIDS in this Case there is a Table of the succession of Pisciferous formations: the colours on the margins of each ticket in the Cases refer to this Index-Table.

Sparnodus. (S. ovalis, and S. macropthalmus, from Monte Bolca.)
Sciænurus. (S. Bowerbankii, eocene clay, Isle of Sheppey.)
Platax. (P. Woodwardii, chiefly teeth from the Crag.)
Ephippus. (E. Bucklandi, Sheppey.)
Naseus. (N. rectifrons, Monte Bolca.)
Semiophorus. (S. velifer, Monte Bolca.)
Rhombus. (R. minimus, Monte Bolca.)
Mugil. (M. princeps, Aix, in Provence.)
Calamopleurus. (C. cylindricus, chalk of Brazil.)
Fistularia. (F. Konigii, from the slate of Glaris.)
Gobius. (G. macrurus.)
Callipteryx. (C. recticaudus.)
Cottus. (C. brevis.)
Ductor. (D. leptosomus, Monte Bolca.)
Lichia. (L. prisca, Monte Bolca.)
Thynnus. (T. propterygius, Monte Bolca.)
Orcynus. (O. elongatus, Monte Bolca.)
Carangopsis. (C. dorsalis, Monte Bolca.)
Gasteronemus. (G. rhombeus, Monte Bolca.)
Cybium. (From the eocene clay, Isle of Sheppey.)
Enchodus. (E. halocyon, chalk, Lewes.)
Anenchelum. (A. Glarisianum, from Engi.)
Palymphes. (Many very fine specimens in Engi slate.)
Isurus. (I. macrurus, Glaris.)
Palæorhyncum. (P. medium, in Engi slate.)

WALL-CASE D.—(24, to 27.)

Tetrapturus. (T. minor, London clay, Sheppey.)
Cælorhyncus. (C. rectus.)
Cladocyclus. (C. Lewesiensis, chalk of Lewes.)
Sphyrænodus. (S. priscus, Bracklesham.)
Pachyrhizodus.
Saurodon. (S. Leanus, Chalk, Lewes.)
Saurocephalus. (S. lanceolatus, from the chalk of Lewes.)
Archæus. (A. Glarisianus.)
Sphenolepis. (S. squamosseus, from Aix; S. Cuvieri, from Montmartre.)
Istieus. (I. microcephalus.)
Hypsodon. (H. Lewesiensis, from the chalk near Lewes, discovered in 1821.)
Esox. (E. lepidotus, from Œningen; a fine series of specimens.)
Tinca. (T. furcata, and T. leptosoma, from Œningen.)

Leuciscus. (L. Hartmanni, from Steinheim; L. papyraceus, from the paper-coal of the Rhine.)
Clupea. (C. Scheuchzeri, from the slate of Glaris.)
Cobitis. (C. longiceps.)
Acrognathus. (A. boops, chalk, Lewes, *ante*, p. 446.)
Aulolepis. (A. typus, from the chalk, Lewes, *ante*, p. 447.)
Lebias. (L. cephalotes.)
Osmeroides. (O. Lewesiensis, and O. Mantelli, from Lewes.)
Tomognathus. (From the Sussex chalk.)
Anguilla. (A. brevicula, A. pachyura, from Œningen.)
Ampheristus. (A. toliapicus, London clay, Sheppey.)
Rhodeus. (R. elongatus.)
Acanthopsis. (A. angustus.)
Mallotus. (M. villosus. The Angmarset, from the West Coast of Greenland.)

Remains of Fishes of the PLACOID ORDER, viz. Teeth, Rays, Spines, Scales, &c. of Chimæroids, Squalidæ or Sharks, Hybodons, Cestracions, Pristides or Saw-fishes, and Rays. These are, for the most part, in the Table-Cases, 2, 4, 6, 8, 10, of the Plan of Room V. *ante*, p. 410.

CHIMÆROIDS:—Ischyodus, Edaphodon, Ceratodus.
SQUALIDÆ:—Carcharodon, Lamna, Otodus, Notidanus, Hybodus, Cladodus.
CESTRACIONS:—Strophodus, Acrodus, Orodus, Ptychodus, Psammodus, Ctenodus, Ctenoptychius, Cochliodus.
ICHTHYODORULITES.—Rays or spines of fins, dorsal or pectoral, belonging to Cestracions, Chimæroids, and other genera of the Shark family:—Spinacanthus, Oracanthus, Ctenacanthus, Asteracanthus, Nemacanthus, Gyracanthus, Leptacanthus, Ptychacanthus.
PRISTIDES, or Saw-fish:—Pristis.
RAYS:—Ætobatis, Miliobates.[1]

*** To MR. DAVIES, the intelligent Assistant, who has charge of this collection, I am much indebted for his obliging attention during my examination of its contents.

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[1] A list of the principal British localities of Fossil Fishes is given in "The Medals of Creation," p. 679.

CHAPTER V.—PART IV.

FOSSIL MAMMALIA.

RHINOCEROS—IRISH ELK—SIVATHERIUM.

FOSSIL RHINOCEROS.—*Wall-case E.*—With the fossil remains of Ruminants described in a previous chapter (*ante*, p. 389), those of the Rhinoceros are very commonly associated. The collection in this Case consists of crania, jaws, many fine series of the teeth, and other parts of the skeleton, of two species of this genus of pachyderms: they are chiefly from the post-tertiary fresh-water deposits in the valley of the Thames. There are also two or three crania of Rhinoceros from the frozen soil of Siberia.

The fossil remains of one species of this genus (*R. tichorinus*), are very abundant all over Europe in the ancient alluvial deposits, and in the bone-caves. The most extraordinary fact relating to the fossil Rhinoceros, is the discovery of the entire carcass in frozen sand, on the banks of the Wilaji in Siberia. The head was large, and sustained two very long horns; there were no incisor teeth; the skin had the appearance of leather, and was thinly covered with short hairs; it was not loose and in large folds as in the living species.[1]

The fossils in this collection belong to the *Rhinoceros tichorinus*,[2] and *R. leptorhinus*.[3] The former is characterised by the prolongation of the nasal bones in front of the nose, and their union with the incisives: the ordinary cartilaginous septum which separates the nostrils being osseous almost to the extremity. The incisor teeth were either rudimentary or altogether absent.

This animal somewhat resembled the two-horned Rhinoceros of the Cape; but the structure of the nose, jaws, teeth, and skin, distinguishes it. It is by far the most common fossil species, and must have anciently existed in immense numbers throughout Europe, and been adapted to inhabit more northern latitudes than the recent species. The Siberian fossils belong to this type.

The other Rhinoceros of which there are remains in the Museum, is the *R. leptorhinus*, which is separated from that last described, not by the difference in the structure of the nostrils, as the name would seem to import, but by well-marked maxillary and dental characters; as demonstrated in "*Brit. Fossil Mammalia*," p. 356.

FOSSIL ELK OF IRELAND, (*Cervus megaceros.*)—*Plan No.* 15.—The shell-marls of Ireland contain in abundance the bones of an animal which, like the Dodo, and the Moa, was once contemporary with the human species, but has long been extinct; the last individuals of the race were, in all probability, exterminated by the early Celtic tribes. The remains of this noble creature generally occur in the deposits of marl that

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[1] See "Wonders of Geology," pp. 152, 171.

[2] "Rhinoceros fossile à narines cloisonnées," of Cuvier.

[3] "Rhinoceros, à narines non-cloisonnées et sans incisives," of Cuvier.

underlie the peat-bogs, which are apparently, like those of Scotland, the sites of ancient lakes or bays. In Curragh great quantities of these bones were found within a small area; the skeletons appeared to be entire, the skull was elevated, and the antlers were thrown back on the shoulders, as if a herd of these Elks had sought refuge in the marshes, and been engulfed in the morass.

This creature far exceeded in magnitude any living Elk or Deer. The skeleton of the largest individual is upwards of ten feet in height to the top of the skull, and the antlers are from nine to fourteen feet from one extremity to the other. The perfect skeleton before us renders a particular description unnecessary. The bones are generally well preserved, of a dark brown colour, with patches of blue phosphate of iron. In some instances they are in so fresh a condition, that the hollows of the long bones contain marrow, having the appearance of fresh suet.

Bones and antlers occur at Walton, in Essex, associated with skeletons of Mammoths, or fossil Elephants,[1] and have recently been discovered by Mr. Mackie, imbedded with great numbers of the teeth, jaws, and detached bones of Rhinoceros, Hippopotamus, Bos, Hyena, &c., in a diluvial deposit at Folkstone.

Remains of this majestic animal have been found collocated with ancient sepulchral urns, stone implements, and rude single-trunk canoes, in such manner as to leave no doubt that this now extinct species was coeval with the aborigines of these Islands.[2]

Sivatherium (*S. giganteum*).— *Wall-case F.*—Among the highly interesting mammalian remains from the Sewalik Hills, of which we shall treat more at large in the next chapter, are those of one of the most extraordinary extinct types of the Order Ruminantia hitherto discovered, the *Sivatherium;* of which there is a fine cranium, lower jaw and teeth, and bones of the extremities in the Case before us.[3]

The skull of this animal approaches in volume that of the Elephant; the neck was shorter and stronger than in the Giraffe; the posterior region of the skull extending from the orbits is greatly developed, and apparently formed cellular protuberances as in the Elephant. The face is short, and the nasal bones are remarkable for the manner in which they are prolonged into a pointed arch above the external nostrils, indicating a trunk or proboscis. The very inclined direction of the front of the face, in relation to the triturating surface of the teeth, imparts a physiognomy altogether peculiar. Two horns rise from the brow between the orbits, and diverge from each

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[1] "Wonders of Geology," p. 134.

[2] See my "Lecture on the Remains of Man and Works of Art imbedded with remains of extinct animals." Delivered before the Archæological Institute of Great Britain, at the Oxford Meeting, June 1850. —*Archæological Journal, for January*, 1851.

[3] The *Sivatherium* (so named from Siva, an Indian deity), was discovered and described by Dr. Falconer and Major Cautley. See a Memoir on the "Sivatherium giganteum, a new fossil ruminant genus, from the valley of the Markanda."—*Journal of the Asiatic Society.*

other; and it is probable that the posterior protuberances of the forehead also supported a pair of short massive horns.

The living Sivatherium must have resembled an immense *Gnu* or Antelope, with a short, thick head, and an elevated cranium crested with two pairs of horns; the front pair small, the hinder large (perhaps palmated), and set behind as in the Aurochs; it had small lateral eyes, great lips, and a nasal proboscis, an organ unknown in all living ruminants. The model of another species (*S. Perimense*), is deposited in the same Case.

LIGN. 98.
SKULL OF THE SIVATHERIUM GIGANTEUM; FROM THE SUB-HIMALAYAS.
($\frac{1}{14}$ *nat. size.*)

CAMELUS (*C. Sivalensis*). — *Wall-case E.*—Crania, jaws and teeth, of a species of Camel, from the tertiary deposits of the Sewalik Hills, are deposited on the upper shelves of this Case; they are in a fine state of preservation. The original was nearly related to the existing species of Camels, but exceeded them by at least one-seventh in height.[1]

There are likewise remains of a species of *Giraffe*, from the same locality, but I have not been able to obtain any precise information respecting them.

CHAPTER V.—PART V.

FOSSIL CEPHALOPODA.

FOSSIL CEPHALOPODA.—*Table-cases* on the south side of Room V.—The six Table-cases on the right of the entrance from Room IV. are devoted to the fossil *Cephalopoda*, and contain an extensive collection of Ammonites, Nautili, and other shells of the mollusca of this order.

The Cephalopoda are composed of a body which is either naked, as in the Sepia or Cuttle-fish, or enclosed in a shell, as in the Nautilus and Argonaut; with a distinct head, eyes as perfect as in the vertebrata, complicated organs of hearing, and a powerful masticatory apparatus, surrounded by arms or tentacula. Below this head there is a tube, which serves as a locomotive instrument to propel the animal backwards by the ejection of water which has served the purpose of respiration, and can be thrown out with considerable force by the contraction of the body. The fossil remains consist of the external shell, and the internal osselet of the Sepiadæ, and rarely of the body and arms, ink-bag, mandibles, &c. as in some splendid examples from the Oxford Clay of Wiltshire, in this collection.

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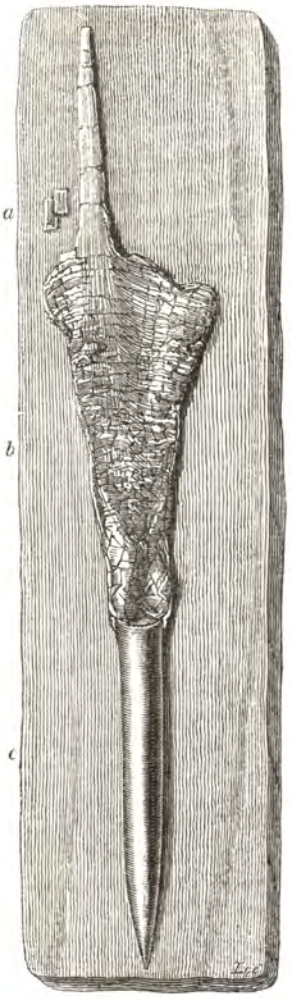
[1] "Note on the fossil Camel of the Sewalik Hills."—*Journal of the Asiatic Society.*

The elegance and variety of form of the shells of the numerous fossil Cephalopoda are beautifully exhibited in the series of Nautili, Ammonites, &c. deposited in these Cases, which comprises a large number of the British species, arranged and named, with their respective geological habitats affixed.



LIGN. 99.
BELEMNITES PUZOSIANUS; OXFORD CLAY, CHRISTIAN MALFORD, WILTS.
($\frac{1}{6}$ *nat. size.*)
a, one of the basal processes of the phragmocone.
b, the *phragmocone*.
c, the rostrum or guard of the osselet, containing the apex of the phragmocone in its upper part.

Our limits will not admit of special notice of any of these specimens, with the exception of some remarkable examples of two genera of naked Cephalopoda, *Belemnites* and *Belemnoteuthis*, in *Table-case* 3, which display every part of the structure of these extinct forms at present known.

BELEMNITES. — *Lign.* 99. *Table-case* 3. — The cylindrical or fusiform stones, terminating in a point at one end and having at the other a conical cavity, of a dark brown colour, and of a radiated sparry structure internally, must be familiar to most of my readers by the name of *Belemnite*, (see *Lign.* 99, *c.*). These stones are the fossil osselets or internal support of an extinct type of cephalopoda allied to the Sepiadæ or Cuttle-fish. In the more perfect specimens, a conical chambered shell, called the *phragmocone*, composed of a series of shallow concave cells, of a nacreous substance, and pierced by a siphunculus, occupies the cavity of the belemnite; and it has recently been discovered that this phragmocone extended to a considerable length, and terminated at the basal or cephalic end, in two long processes; and that a horny capsule or integument invested the belemnite and the phragmocone, so as to form a receptacle in which the viscera of the animal were probably contained. These structures are very rarely found in the same specimen; but the very fine Belemnite in the Case before us, (collected by MR. BUY, of Chippenham, who is well known for his skill and sagacity in discovering and developing fossils of this kind,) displays the several parts very distinctly; they consist of,—

1. An external *Capsule*, which invested the *guard*, or osselet (*sepiostaire*), and extending upwards, constituted the external sheath of the receptacle.

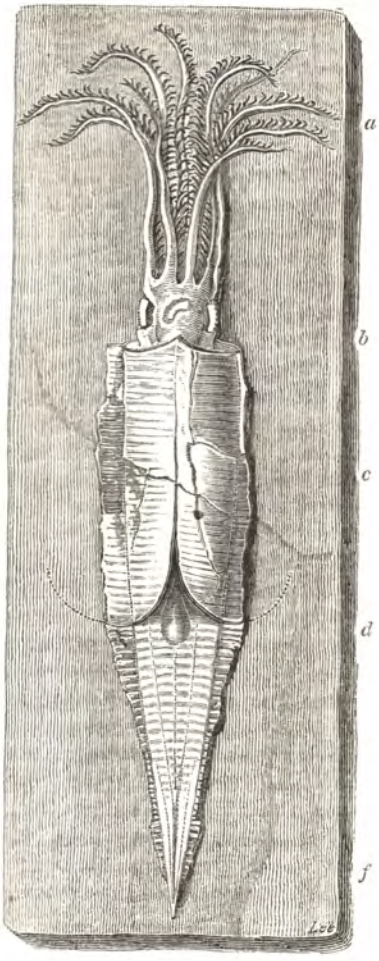
2. The *Osselet*, characterised by its fibrous radiated structure, terminates distally in a solid rostrum or guard, (*c*,) which has an alveolus, or conical cavity, to

receive the apical portion of the chambered phragmocone, and expanding proximally, becomes confluent with the capsule.

3. The *Phragmocone*, or chambered, siphunculated, internal shell, (*b*,) the apex of which occupies the cavity of the guard, and the upper part constitutes a capacious chamber, from the basilar margin of which proceed two long, flat, testaceous processes, (*a*.).

These structures comprise all that are at present known of the animal to which the fossil commonly called "*Belemnite*" belonged.

In the specimen discovered by my son, Mr. Reginald Neville Mantell, in the Oxford Clay, near Trowbridge, (and which first showed the investing capsule of the guard and phragmocone, and the processes of the latter,) there is a thin layer of a carbonaceous substance of a fibrous structure, spread over the interspace between the elongated processes; and this is the only trace of the soft parts of the animal of the Belemnite, that has come under my observation.[1]



LIGN. 100.—BELEMNOTEUTHIS ANTIQUUS, FROM OXFORD CLAY, CHRISTIAN MALFORD, WILTS. (⅓ *nat. size.*)

(*Drawn by S. P. Woodward, Esq.*)

a. The arms, and tentacula.
b. Remains of the head.
c. The mantle, with indications of lateral fins.
d. The ink-bag, covered by the pallial integument.
e. The osselet; the transverse lines indicate the septa of the phragmocone.
f. The apex or rostrum of the osselet.

BELEMNOTEUTHIS. — *Lign.* 100. *Table-case* 3. — Associated with the Belemnites in the Oxford Clay of Wiltshire, there are great numbers of the osselets of a cephalopod allied to the Sepiadæ, which the late Channing Pearce, Esq. of Bath, described under the name of *Belemnoteuthis antiquus*, in a communication to the Geological Society, in 1842. Mr. Pearce stated, "that the lower part of this cephalopod is conical, blunt at the apex, and chambered internally, like the alveolus (*phragmocone*) of a Belemnite, with a siphunculus near the edge of the chambers. It has a brown thick shelly covering, which gradually becomes thinner towards the upper part. Above the cham-

[1] See my "Pictorial Atlas of Organic Remains," p. 171.

bers there is an ink-bag lying on what appears to be part of a sepiostaire, for it is a yellowish substance, finely striated transversely, and composed of laminæ of unequal density."[1] The soft body of the animal, of an elongated form, with a pair of lateral fins, two large sessile eyes, eight uncinated arms, a pair of long tentacula, and a sac, or ink-bag, containing the inspissated sepia, are preserved in juxtaposition in several examples discovered by Mr. Pearce, Mr. Buy, my son, and other collectors. A splendid specimen in the Case before us shows these several parts. (*Lign.* 100.)

The osselet, or guard of the Belemnoteuthis, like that of the Belemnite, is of a fibro-radiated structure, and contains a chambered shelly phragmocone; it is of a horny texture, and is never fossilized by calcareous spar, as is almost invariably the case with that of the Belemnite.

Professor Owen, in a communication to the Royal Society in 1844,[2] described the Belemnoteuthis as the soft parts of the Belemnite; a mistake the more extraordinary as Mr. Channing Pearce's correct interpretation of the true nature of the Belemnoteuthis was published two years previously. Professor Owen, assuming that the osselet of the latter (see *Lign.* 100, *e, f.*) was the phragmocone of the former separated from its rostrum or guard, (*Lign.* 99, *c,*) blended these two distinct genera into one, and gave a restored figure of the animal, based on this erroneous idea of the Belemnite (*Philos. Trans.* 1844, Pl. VIII.).[3] The discovery of some remarkably perfect Belemnites by my son, when constructing a branch of the Great Western Railway, first drew my attention to the subject, and convinced me of the mistake into which Professor Owen had fallen, and of the accuracy of the original interpretation of Mr. Channing Pearce, which that sagacious and acute observer, Mr. Charlesworth, had always declared to be the true one. The result of my investigations was communicated to the Royal Society, and is published in the *Phil. Trans.* 1848, and 1850.[4]

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[1] "Proceedings of the Geological Society," vol. iii. p. 593.

[2] "A Description of certain Belemnites found with a great proportion of their soft parts, in the Oxford Clay, at Christian Malford in Wiltshire."—*Phil. Trans.* 1844, p. 65. For this memoir one of the Royal Medals was awarded.

[3] An abstract of this memoir, and a figure of the cephalopodous mermaid as that of the animal of the Belemnite, are given in my "Medals of Creation," p. 468, for which I beg to apologise to the purchasers of that work; the error will be corrected in the edition now in preparation. See "Pictorial Atlas of Organic Remains," article *Belemnite*, p. 170.

[4] In those communications I most studiously endeavoured to avoid giving offence to the eminent anatomist, whose genius and industry I so much admire, and whose scientific labours I have so highly eulogized, and have done everything in my power to promote, by placing at his disposal original drawings of considerable value, and hundreds of specimens collected by my son; but, alas! to doubt Professor Owen's infallibility was a deadly sin, and I have no hope of forgiveness! hence originated the "*unamiable exaggerations*," and "*misrepresentations*," which I have been compelled in self-defence, and to my deep regret, to notice in a previous chapter (*ante*, p. 192).

CHAPTER VI.

PART I.

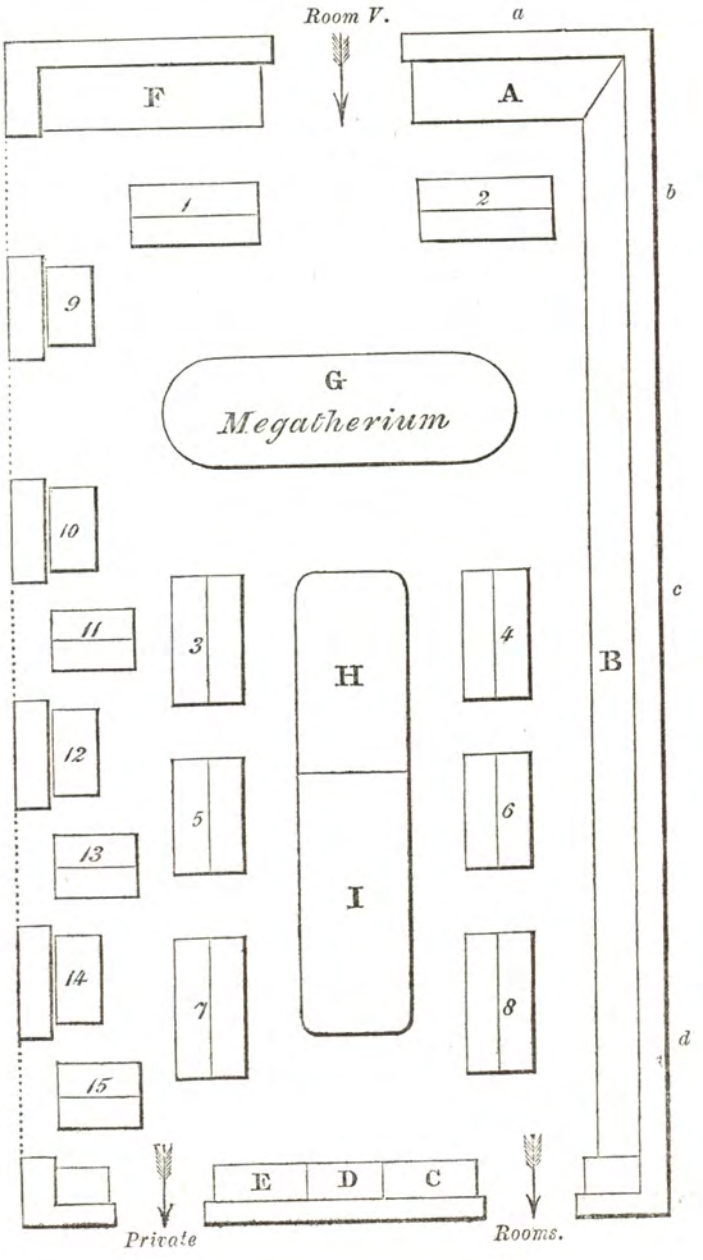
PLAN OF ROOM VI. — SYNOPSIS OF CONTENTS — ELEPHANTS AND MASTODONS FROM THE SEWALIK HILLS—MAMMALIAN BONES FROM CAVES IN BRAZIL —FOSSIL HUMAN SKELETON—MAMMALIAN BONES FROM KIRKDALE, TORQUAY, AND GAILENREUTH CAVES—PALÆOTHERIA AND ANOPLOTHERIA— MEGATHERIUM — ELEPHAS GANESA — MASTODON OHIOTICUS — TUSKS AND BONES OF MAMMOTHS AND MASTODONS — FOSSIL ECHINODERMS, CRUSTACEANS, AND BRACHIOPODA—FOSSIL ZOOPHYTES — FOSSIL ALLIGATOR OF HORDWELL—DINOTHERIUM—HIPPURITES AND SPHERULITES.

WE now enter the last room of this noble Gallery of Organic Remains; it is in a great measure appropriated to the fossil relics of extinct mammalia, and especially to those of the colossal *Proboscidean Pachyderms*, and *Edentata*. The *coup d'œil* is very imposing, for the model of the gigantic *Megatherium* arrests the attention of the visitor on entering the apartment, and beyond it stands the fine skeleton of the *Mastodon* of the Ohio; and between these two grand monuments of a former state of the globe, is the skull with its enormous tusks, of an extinct species of Elephant from India; while the surrounding Cases exhibit a splendid collection of crania, jaws, teeth, tusks, and bones, of various species of the same tribes of mammalia.

The history of these highly interesting objects must be familiar to the intelligent reader, for almost every one has heard of the Mammoths entombed in ice in Siberia,[1]—of the Mastodons swamped in the ancient morasses of North America,[2] —of the colossal beings of the Sloth tribe, whose skeletons are imbedded in the alluvial plains of the Pampas,[3]—and of the fossil remains of similar animals, together with those of other genera of Mammalia and Reptiles, in the tertiary deposits of

[1] "Wonders of Geology," p. 152. [2] Ibid. p. 156. [3] Ibid. p. 164.

PLAN OF ROOM VI.



the Sub-Himalayan mountains.[1] The petrified *Human Skeleton* from the coral-rocks of Guadaloupe must also be well known from the figures and descriptions of this interesting fossil, that have appeared in every elementary work on Geology.[2]

It will, therefore, be unnecessary, in reviewing this grand assemblage of Organic Remains, to enter so largely on the nature and history of the respective objects, as I felt it necessary to do in attempting to render many of the fossils contained in the rooms we have passed under examination, intelligible and interesting to the unscientific observer; and the limits necessarily prescribed to this volume, render details inadmissible. Under the following general heads, the most important specimens will be concisely noticed; I. Synopsis of the Contents of Room VI. II. Fossil Mammalia from the Sewalik Hills. III. Mastodons and Elephants of North America. IV. Mammalian remains from the Tertiary formations of Europe. V. The Megatherium and other fossil Edentata of South America. VI. Fossil Mammalia of the Caverns. VII. Petrified Human Skeleton of Guadaloupe.

The fossil *Invertebrata* in the Table-cases are so well arranged, and so distinctly labelled, as to be readily understood and identified, and require no especial description.

ROOM VI.

(*70 feet long.*)

Synopsis of Contents.

Wall-cases *A* and *B*.—The cases on the left or south side of this room contain an extensive and matchless collection of the fossil remains of Elephants and Mastodons; the suite of crania, jaws and teeth, and tusks, comprises specimens of extraordinary interest, and would alone confer celebrity on any Gallery of Organic Remains. These petrifactions are chiefly from the Tertiary deposits of the Sewalik Hills, in Northern India, and were collected by Major Proby T. Cautley, and Dr. Falconer; there are likewise some fine examples of similar parts of skeletons of Mammoths and Mastodons from the alluvial beds of North America.

The skulls and teeth of the Elephantine family commence in *Case A*, and the specimens are placed serially according to their affinity to the kindred group, the Mastodons. The latter occupy the western end of *Case B;* and the transitional types are placed in the central division of the cabinet; thus constituting a most instructive series of the crania, and maxillary and dental organs, of the extinct forms of proboscidean pachyderms.

The skulls are named and arranged in the following order:—

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[1] "Wonders of Geology," p. 162. [2] Ibid. p. 88.

ELEPHANTS.

1. Elephas Namadicus, from India.
2. ——— planifrons, ———.
3. ——— insignis, ———.
4. ——— Ganesa, ———.
5. ——— bombifrons, ———.
6. ——— Hysudricus, ———.

In Case *A*, there are likewise teeth and tusks of the European fossil Elephants; viz.—

Elephas priscus.
——— meridionalis.
——— primigenius.

These specimens are not labelled.

MASTODONS.

7. Mastodon Andium, South America. A magnificent cranium and tusks of this species; and a rich series of teeth from Buenos Ayres.
8. Mastodon Ohioticus, North America.
9. ——— Perimensis, India.
10. ——— Sivalensis, ———.
11. ——— latidens, ———.

——— angustidens, Europe.
——— longirostris, ———.
——— Arvernensis,[1] ———.

The crown of a molar tooth of this species, from the Crag, figured by Dr. Smith in the frontispiece of his "Strata identified by Organic Remains," is placed in this Case.

Wall-case C, is devoted to fossil mammalia from the caves of Minas Geraes in Brazil. The upper division contains some fine bones of the *Scelidotherium*, an animal allied to the Megatherium, and portions of the dermal cuirass of *Glyptodon*, and *Chlamydotherium;* and bones of a large species of *Machairodus*. In the lower compartment are similar remains, and bones and teeth of existing mammalia from the same caves, belonging to species of *Monkey*, *Opossum*, &c.; with these are associated shells incrusted with stalagmite of a large existing terrestrial mollusk (*Bulimus*).

Wall-case D.—A fossil HUMAN SKELETON, imbedded in modern concretionary limestone, from the sea-shore of the island of Guadaloupe; presented by Admiral the Honourable Sir Alexander Cochrane. The table in front of this Case, is a slab of the rock in which the skeleton was imbedded.

Wall-case E.—A very choice collection of skulls, jaws, teeth, &c. of Bears, Hyenas, and other carnivora, from the caves of Gailenreuth in Germany, Kirkdale in Yorkshire, and Torquay in Devonshire.

Wall-case F.—In this Case, which is on the right of the entrance from Room V. (see plan, *ante*, p. 462), are specimens and models of Palæotheria, Anoplotheria, and allied extinct genera of pachyderms from the eocene deposits of France; principally from the gypsum quarries at Montmartre, near Paris. Several of the specimens, and the greater part of the models, were formerly in my collection, having been given me by Baron Cuvier. On the uppermost shelf there is a fine example of the upper and lower jaws with teeth, collected and presented to me by M. Constant Prevost: and a beautiful lower jaw imbedded in limestone, which I obtained from a quarry at Montmartre, and succeeded in exposing it in its present perfect state.

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[1] *M. Arvernensis*, so named from Auvergne, the district in which this species was first identified. I would here supply an omission in the account of the Fossil Mammalia from the Tertiary deposits of Auvergne, given in a previous Chapter; *ante*, p. 353. The collection should have been described as having been formed in part by *M. Croizet;* most of the specimens exhibited were purchased of this eminent observer; many of M. Pomel's are not yet arranged.

G.—Skeleton of Megatherium Cuvieri *vel* Americanum.—This was modelled from the original separate bones; some of which are in this collection, and others in the Hunterian Museum of the Royal College of Surgeons. It is twelve feet long, and eight feet high. The annexed outline (*Lign.* 112), is the first published representation of this interesting skeleton, and has been drawn with great care by the eminent artist, Mr. Joseph Dinkel.[1]

H.—Skull and tusks, of Elephas Ganesa; a remarkable fossil Elephant, from India; presented by Major Baker, of the Bengal Engineers.

I.—Skeleton of Mastodon Ohioticus, or Mastodon of the Ohio, from North America; it is 9 feet 7 inches high, and 20 feet long. The tusks are 7 feet 2 inches in length, and 9 inches in diameter. On the same platform there are 5 bones of the fore-foot (3 carpals and 2 metacarpals), nearly twice as large in linear dimensions as the corresponding parts in the above skeleton, of the *Elephas meridionalis*, dug up in the brick-field at Grays, in Essex.

Under the above skeleton, is placed the model of a perfect cranium and lower jaw of a very young Mastodon; the germs of the tusks are just appearing: it measures 2 feet from the front of the jaw to the occiput, and 1½ from the summit of the skull to the inferior margin of the lower jaw.

On the top of the Wall-cases.

A. a. A fine series of tusks of the Mammoth (*Elephas primigenius*), from Drift; some of them are from the Arctic regions, and were brought home by the Officers of the Expedition sent in search of Sir J. Franklin. Among these is an enormous tusk curved upwards in a spiral direction, which is of the extraordinary length of 12½ feet: it was dug up in frozen gravel on the banks of Mackenzie River.

B. b. Bones of Mammoths from the alluvium of North America; and of Elephants and Mastodons from the Sewalik Hills.

c. Skulls of the existing *Indian Elephant* of the two varieties,—one with short, the other with long tusks.

d. Bones of Mastodons (*Mastodon Ohioticus*), and Mammoths (*Elephas primigenius*), chiefly of the extremities, vertebræ, &c. from the alluvial deposits of North America: some of them are from *Big-bone Lick*, others from the State of Missouri.

Table-cases *and* Upright-cases; *on the north side of Room VI.*

1. Echinites, or fossil Echinoderms. An extensive suite of species and genera from various formations, (at present in Table-case 1, Room V.) will occupy this cabinet. The specimens are admirably arranged and named, so as to be easily identified and examined. It is a most instructive collection for the palæontological student, for it comprises a considerable number of the fossil genera of this order of Radiata, viz.—

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[1] Of 17, Upper King Street, Bloomsbury Square.

Ananchytes, Echinocorys, Echinolampas, Holaster, Galerites, Cidaris, Diadema, Acrosalenia, Glypticus, Disaster, Pygurus, Clypeaster, Scutella, Salmasis, Echinocyanus, &c.[1] There is also a good series of echinital spines. The Chalk Cidarites with spines, and those from the Oolite, are very beautiful; many of my choicest examples of Echinoderms discovered in the Chalk of Sussex are in this cabinet.

2. In this Table will be deposited a collection of fossil Insects and Crustaceans. Among the former are beautiful specimens of Neuroptera, Diptera, &c. from the eocene strata of Aix, in Provence. There is a remarkable and unique fossil wing of an insect in an ironstone nodule from Coalbrook Dale, discovered by me, and named *Corydalis Brongniarti*.[2]

The fossil crustaceans are chiefly of the extinct family of *Trilobites*, and comprise many species from the palæozoic strata.[3]

There are also species of Astacidæ allied to the Lobster and Crayfish, and of Canceridæ, from the Chalk, (*Astacus Leachii, A. Sussexsiensis*, figured in my "Fossils of the South Downs");[4] and others of the same family from Solenhofen. There are likewise a few crustaceans from the tertiary deposits of the Isle of Sheppey, Malta, &c.

3. A miscellaneous collection of fossil zoophytes, ventriculites, choanites, &c. the greater part from the chalk of Sussex, collected by the Author.[5]

Table-case 4. Fossil Corals. A miscellaneous collection of Zoophytes.

5. A very fine series of (*Terebratulæ*) *Brachiopodous* shells, named and arranged by Mr. Woodward. A most instructive and beautiful collection, comprising many unique, and rare examples.

6. Unoccupied.

7. Another fine series of fossil *Brachiopodous* shells; comprising many species of the genera *Spirifer, Orthis, Leptæna, Productus, Crania, Lingula*, &c.[6]

8. Unoccupied.

9. (*Upright-case*, 4)—This Case contains on the upper shelf the cranium and lower jaw of the *Megatherium*, from which the cast of the restored skeleton was taken: in the middle compartment there are ribs and vertebræ, and in the lowest a series of the caudal vertebræ, sixteen in number, as perfect as in a recent skeleton.

10. (*Upright-case*, 3.) Other remains of the *Megatherium:* here are the originals of the bones of the feet, and of the humerus, and ulna, of the model.

11. (*Table-case.*) A highly interesting collection of jaws, teeth, and

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[1] See "Medals of Creation," ch. xi. p. 340.

[2] "Medals of Creation," vol. ii. p. 578.

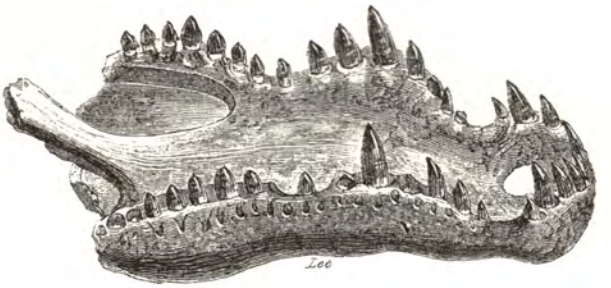
[3] Ibid. p. 552.

[4] Ibid. p. 536.

[5] For a popular account of Ventriculites and Choanites, see "Thoughts on a Pebble, or a first Lesson in Geology," 8th edition, with numerous plates.

[6] "Medals of Creation," p. 378.

bones, of several species of Crocodile, Alligator, and other reptiles, from the Eocene deposits at Hordwell, Hants: collected and presented to the British Museum by Searles Wood, Esq. F.G.S.



Lign. 101. Alligator Hantoniensis; from Hordwell.
($\frac{1}{5}$ *nat. size.*)

Alligator Hantoniensis. — This fine lower jaw was figured and described in the "London Palæontological Journal," Pl. I. It closely resembles that of a species of Crocodile (*C. Hastingsiæ*), discovered by the Marchioness of Hastings in the same locality; but the presence in the upper jaw of the sockets for the reception of the inferior canines when the mouth is closed, establishes its generic character.

First Caudal Vertebra of Crocodilus Hastingsiæ. —I would direct attention to another fossil in this Case, in illustration of a fact described in a former chapter, (*ante*, p. 168.) The first vertebra of the tail of a species of Crocodile, showing the double convexity of the centrum. (*Lign.* 102.)

Lign. 102.
First caudal vertebra of Crocodilus Hastingsiæ.
($\frac{1}{4}$ *nat. size.*)

12. (*Upright-case*, 2.) Model of the cranium, and of the lower jaw and tusks, of the *Dinotherium giganteum*, from the miocene strata at Epplesheim, by Mr. Kaup. This skull, including the lower jaw, is about 2 feet high, and 3 feet long from chin to occiput; the tusks, including the projecting sockets sent off from the lower jaw, are 3 feet in length; the excluded tusks measuring 15 inches. This Case contains also a fine suite of molar teeth.

*** Femur from Epplesheim, supposed to belong to the Dinotherium: a model in the recess of the window; length, 4½ feet; circumference of the shaft, 25 inches; of the head of the bone, 29 inches.

13. (*Table-case.*) A miscellaneous collection of Reptilian remains from the Wealden of Tilgate Forest, (from the collection of the Author,) are placed here provisionally. There are many highly interesting specimens in this Case, that were obtained with much labour and trouble from the strata of Tilgate Forest; but until they are classified and labelled, any attempt to refer to a particular fossil would be useless.

14. (*Upright-case*, 1.) Model of one ramus of the lower jaw, with tusk,

of Dinotherium. A very fine specimen of part of the cranium, with the maxillary bones and six molars of a Dinotherium from Epplesheim; purchased of M. Kaup.

15. (*Table-case.*) Fossil Brachiopodous shells of the order *Rudistes*, comprising some beautiful examples of Hippurites, Spherulites, &c. Among these is a fine specimen from Mr. Dixon's collection, of a species discovered by me in the chalk of Sussex, and named *Spherulites Mortoni.*[1] There are likewise fossil *Balani*, *Serpulæ*, &c. but their arrangement is only provisional.

Fossil Jaw of a Whale, from the Elephant-bed, Brighton Cliff.— There were formerly in this room several portions of the left ramus of the lower jaw of a Whale, discovered in the ancient shingle-bed associated with bones of Elephants, in the cliff to the East of Brighton.[2]

CHAPTER VI.—Part II.

FOSSIL MAMMALIA OF THE SEWALIK HILLS.

Palæontology of the Sewalik Hills.— *Wall-cases A. and B.*— The splendid collection of fossil bones in the Cases before us, is almost wholly the result of the researches of Major Proby Cautley and Dr. Falconer, in the tertiary deposits of the Sub-Himalayas or Sewalik[3] range, which skirts the southern base of the Himalayas, and attains an altitude of from one to three thousand feet above the level of the sea. The strata in which these remains were found consist of concretionary grit, conglomerate, sandstone, and loam, and are spread over the flanks of the hills, and extend about 200 miles in length, with an average breadth of about 7 miles, and dip to the north at an angle of from 20° to 30°. Wherever gullies and fissures, or water-courses, exposed sections of the beds, abundance of fossil bones were met with. Lignite and trunks of dicotyledonous trees, and a few freshwater and land shells, were found mingled with the animal remains; and some vestiges of a species of fluviatile fish related to the recent *Silurus.* The bones in the sandstone and conglomerate are very much in the condition of those of the reptiles in the Wealden grit, and are as difficult to clear from the rock, as I had personal experience in a fine collection sent to me in 1836, from Suharunpoor, by Major Cautley; and I can, therefore, duly appreciate the labour and skill bestowed on the specimens in the British Museum, by Mr. James Dew, by whom these interesting fossils were developed.

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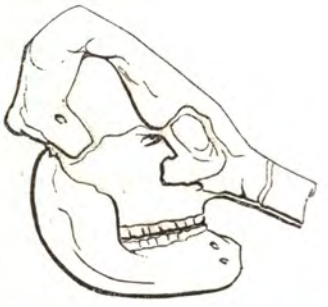
[1] "Medals of Creation," p. 430, *Lign.* 98.

[2] See "Medals of Creation," p. 824.

[3] "*Sewalik*, a corruption of Siva-wâla, a name given to the tract of mountains between the Jumna and the Ganges."—*Major Cautley.*

The following extract from the prospectus of a work on these fossils, by Dr. Falconer, will convey some idea of the rich and extraordinary assemblage of mammalian remains which have been collected from the Sewalik deposits.

"This fossil Fauna is composed of representative types of mammalia of all geological ages, from the oldest of the tertiary periods down to the most modern; and of all the geographical divisions of the Old Continent, grouped together into one comprehensive assemblage. Among the forms contained in it there are of the *Pachydermata*, several species of Mastodon, Elephant, Hippopotamus, Rhinoceros, Anoplotherium, and three species of Equus: of the *Ruminantia*, the colossal genus Sivatherium (*ante*, p. 457), which is peculiar to India, with species of Camelus, Bos, Cervus, and Antelope; of the *Carnivora*, species of most of the great types, together with several remarkable undescribed genera; of the *Rodentia* and *Quadrumana*, several species; of the *Reptilia*, a gigantic Tortoise (*Colosso-chelys*, *ante*, pp. 11, 77), with species of Emys and Trionyx, and several forms of Gavials and Crocodiles. To these may be added the remains of Struthious and other Birds: and Fishes, Crustacea, and Mollusca."[1] Thus, in the Sub-Himalayas we have entombed in the same rocky sepulchre, bones of the



LIGN. 103.—CRANIUM AND JAWS OF ELEPHAS PLANIFRONS. ($\frac{1}{24}$ *nat. size.*)

LIGN. 104.—CRANIUM AND JAWS OF ELEPHAS NAMADICUS. ($\frac{1}{24}$ *nat. size.*)

most ancient tertiary races of mammalia and reptilia, with those of species actually existing in India at the present time.

ELEPHANTS AND MASTODONS.—The Elephants of the Sewalik Hills, of which there are crania and teeth in the collection, comprise six species, as specified in the Synopsis; and I would direct particular attention to

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[1] "Fauna Antiqua Sivalensis, being the Fossil Zoology of the Sewalik Hills in the North of India." By Dr. Falconer and Major Proby T. Cautley. London: 1846.

the cranial peculiarities and physiognomy of *Elephas planifrons*, distinguished by the flatness of the forehead (*Lign.* 103), and the intermediate character of its molar teeth; *E. Namadicus*, with a great vertical development of the cranium (*Lign.* 104), and teeth closely allied to those of the Indian species; and the enormous turban-like vertex of the skull of *E. Hysudricus* (*Lign.* 105), the structure of whose teeth approaches that of the African Elephant.

LIGN. 105.—CRANIUM AND JAWS OF ELEPHAS HYSUDRICUS. ($\frac{1}{24}$ *nat. size.*)

Elephas Ganesa.—In the centre of Room VI. (*H.* of the plan, *ante*, p. 462). Among the Indian fossil elephants there is one species remarkable for the enormous size of the tusks in proportion to the skull; of this animal there is a splendid specimen deposited in the centre of this room. The total length of the cranium and tusks is fourteen feet; length of the skull, four feet two inches; width, twenty-nine inches;

LIGN. 106.—CRANIUM AND TUSKS OF ELEPHAS GANESA.
(*The original is* 14 *feet long.*)

width of the muzzle, two feet; length of the tusks, ten feet; circumference of the tusk at the base, twenty-six inches.

MASTODONS.—The fossil remains of this extinct tribe of the elephantine family, thus named from the peculiar form of the crowns of the molar teeth, are found in equal abundance with those of the Elephants in the Sewalik tertiary deposits, and four species have been determined by Dr. Falconer, as enumerated in the Synopsis, (*ante*, p. 464.)

The Mastodons resembled the Elephants in their general character; having a convex cellular cranium, large tusks in the upper jaw, and a

long trunk or proboscis. The molars differ from those of the Elephant in their simple crown composed of dentine and enamel, disposed in large transverse tubercles, each of which is subdivided into two obtuse points or mastoid processes, which by use are worn into disks more or less wide, according to age; these transverse ridges are not filled up with cement. There are a greater number of grinders simultaneously in each jaw, than in the Elephant; and although the succession of the back grinders is antero-posterior as in the latter, the first and second molars, both in the upper and lower jaw, are replaced in a vertical direction by a tooth of a simpler form than the second molar.

A still more remarkable peculiarity is the existence in the lower jaw in the young Mastodon, of two small, short, straight tusks, that project from the anterior extremity; and these disappear as the animal advances to maturity, except in the tusks of some adult male species, in which one or both are retained.

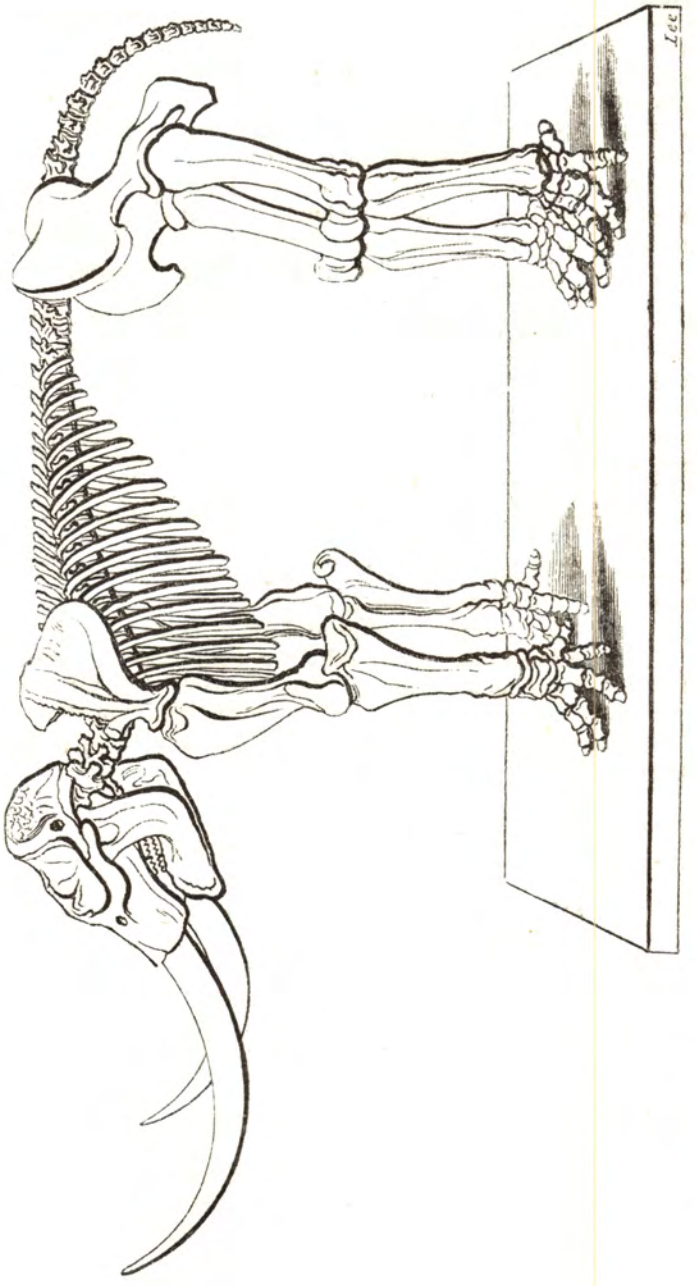
But there are transitional forms of Mastodons from Ava, described by the late Mr. Clift, in which the characters of the molars are intermediate, as indicated by the name *M. elephantoides;* and Dr. Falconer affirms that the presumed distinctive characters are far from being absolute, for premolars are developed in greater number in one typical fossil species of Elephant than in any known Mastodon; and though the inferior tusks have been detected in three species of Mastodon, there are other forms in which, even in the young state, no traces of such dental organs are perceptible.

Lower Jaw of Mastodon with Tusk.—On the middle shelf of Wall-case *B*, in the fifth division of the cabinet, reckoning from the west end of the room, there is a remarkably fine and instructive specimen of a lower jaw of *Mastodon Ohioticus*, in which a tusk is seen retained in the socket of the right side. This jaw has on each side three molar teeth, the crowns of which are but slightly worn; and the root of the tusk is distinctly exposed in consequence of the mesial aspect of the socket having been broken away.

CHAPTER VI.—Part III.

MASTODONS AND ELEPHANTS OF NORTH AMERICA.

Skeleton of the Mastodon of the Ohio (*Mastodon Ohioticus*).—Room VI. I.—This fine skeleton was purchased by the Trustees of the British Museum, of *Albert Koch*, a well-known collector of fossil remains, who had exhibited in the Egyptian Hall in Piccadilly, under the name of the "*Missourium*, or Leviathan of the Missouri," an enormous osteological monster, constructed of the bones of this skeleton, together with many belonging to other individuals, the tusks being fixed in their sockets so as to curve outwards on each side of the head. From this heterogeneous assemblage of bones, those belonging to the same animal were selected, and are articulated in their natural



LIGN. 107.—SKELETON OF THE MASTODON OHIOTICUS; FROM NORTH AMERICA. (*Height 9½ feet: length 20 feet.*)

juxtaposition. Many fine examples of teeth and jaws, and other parts of the skeleton of the American Mastodon, from the same collection, are deposited in the Cases before us.

According to the narrative of M. Koch, these remains were found "near the banks of the river *La Pomme de Terre*, a tributary of the Osage River, in Burton County in the State of Missouri, 40° lat. 18° long." The bones were imbedded in a brown sandy deposit full of vegetable matter, with recognisable remains of the cypress, tropical cane, and swamp-moss, stems of the palmetto, &c., and this was covered by beds of blue clay and gravel to a thickness of about fifteen feet. Mr. Koch states (and he personally assured me of the correctness of the statement) that an Indian flint arrow-head was found beneath the leg-bones of this skeleton, and four similar weapons were imbedded in the same stratum: he avers that he raised them out of the bed with his own hands.[1]

The other North American remains of Mastodons in the Museum are chiefly from *Big-bone Lick*, a celebrated morass or bog, in Kentucky, about twenty-three miles in a south-west direction from Cincinnati. Imbedded in the blue clay of this ancient Creek, the entire skeletons, or separate bones, of not less than 100 Mastodons, 20 Mammoths, (*Elephas primigenius*,) a few bones of the *Megalonyx*, and of a species of Stag, Horse and Bison, are said to have been discovered.[2]

The following measurements (for which I am indebted to Mr. Waterhouse), will convey an idea of the size and proportions of this skeleton. Extreme length, 20 ft. 2 in.; height, 9 ft. 6¾ in.; *cranium*, length, 3½ ft.; vertical dimension, 4 ft.; width, 2 ft. 11 in.; width of pelvis, 5 ft. 8 in.; tusks, extreme length, 7 ft. 2 in.; projection of the same, 5 ft. 2 in.; circumference at the base, 27 in.

On the pedestal, and under the above skeleton, is placed a model of the cranium and jaws of a young Mastodon, of the same species. The tusks in the lower jaws are wanting.

LIGN. 108.
CRANIUM AND JAWS OF A YOUNG MASTODON OHIOTICUS: FROM BIG-BONE LICK.
($\frac{1}{20}$ *nat. size.*)

MAMMOTH (*Elephas primigenius*). —*Wall-case A*.—The species of fossil Elephant distributed in the Drift of Europe, and whose bones, ivory tusks, and even the entire carcasses covered with skin and bone, occur in the icy regions of Siberia, is generally known by the name of Mammoth. The teeth and tusks of this species are so common in this country, that scarcely a local museum is destitute of

[1] "Description of the Missourium, by Albert Koch." Louisville, 1841, p. 20.

[2] See "Travels in North America," by Sir Charles Lyell, 1845, vol. ii. chap. xvii.; or my "Pictorial Atlas of Organic Remains," p. 167.

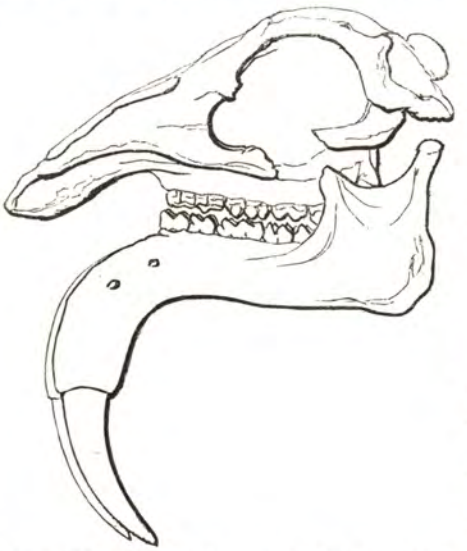
specimens. I therefore need only refer the reader unacquainted with the highly interesting history of the discovery of the carcass of this species in the frozen soil of the banks of the Lena, to "Wonders of Geology," p. 152; and point out to the visitor the fine teeth and crania in the *Wall-case A*, and the enormous tusks obtained from the Arctic regions, that are placed above.

Elephas meridionalis.—This species is found in the newer tertiary deposits, and is comparatively rare in this country; there are teeth and bones from the Norwich Crag, and from Grays, in Essex. From this last named locality was obtained the series of bones of the foot placed on the pedestal *I;* there are three carpals, and two metacarpals; the middle metacarpal is eight inches long, and four inches wide; twice the size of the corresponding bones in the skeleton of the mammoth.

CHAPTER VI.—PART IV.

FOSSIL MAMMALIA OF THE TERTIARY FORMATIONS.

DINOTHERIUM.[1]—*Wall-cases* 12, 14.—This extinct mammalian was first known by some large molar teeth, described by Baron Cuvier as belonging to a gigantic animal related to the Tapir, and which he designated "*Tapir gigantesque.*" Subsequently, the entire skull and lower jaws were discovered in Miocene sand, near Epplesheim, by M. Klipstein, and described by M. Kaup. The model in the Museum is from this celebrated specimen; the original is now, I believe, in the *Jardin des Plantes,* having been purchased by the French Government.



LIGN. 109.—CRANIUM AND JAWS OF DINOTHERIUM GIGANTEUM, FROM EPPLESHEIM. ($\frac{1}{30}$ *nat. size.*)

The skull is characterised by a very flat occiput, large nasal apertures opening above, large suborbital fossæ, which, together with the form of the nose, indicate the existence of a short trunk, or proboscis. The lower jaw has in front two enormous tusks directed downwards, and gently curved inwards; the molar teeth ($\frac{5}{5}$) resemble those of the Tapirs and Lamantins. The annexed figure will enable the reader to identify the specimen, and distinguish the most essential characters.

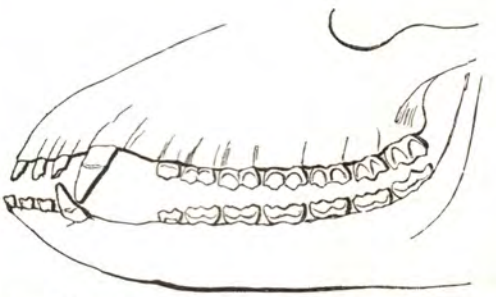
[1] The enormous size of the skull, and the powerful tusks, suggested the name *Dinotherium.*—"Medals of Creation," p. 832.

M. Kaup considers the Dinotherium to have belonged to an extinct genus of pachyderms, the form and structure of the molar teeth indicating an approach to the Mastodons and Tapirs; but M. Blainville and M. Pictet regard it as an herbivorous cetacean, which inhabited the embouchures of great rivers; and they suppose that the large tusks of the lower jaw served for uprooting the marsh and aquatic plants which constituted its food. As the cranium and jaws are the only known parts of the skeleton, these physiological inferences are based on their form and structure; but until bones of the extremities are discovered, no positive conclusion can be obtained. The restored figure of the Dinotherium, as a terrestrial pachyderm, is given in (see "Wonders of Geology, p. 174) most works on palæontology. M. Pictet, in his valuable treatise on Palæontology, has introduced an outline of the animal as an aquatic herbivore, resembling the Lamantin. If the femur in Window-recess, *ante*, p. 467, really belonged to the Dinotherium, the terrestrial habits of the original would be satisfactorily established; but at present the reference of that bone to the Dinotherium is only hypothetical.

Cuvierian Pachyderms.— *Wall-case F.*—In this cabinet are deposited specimens and models of bones and teeth of extinct pachyderms, belonging to a group of genera differing from all living forms, and which constituted the most striking feature of the mammalian fauna of the ancient tertiary epochs in Europe. They are most nearly allied to the Tapirs, which are natives of warm climates, one species inhabiting India, and two America. In the tertiary ages Tapirs and these allied forms existed in those regions of the globe, and in Europe: their fossil remains occur in the caves of Brazil, in the sandstone conglomerate on the banks of the Irawadi in the Burmese empire, and in the Sewalik Hills; in the sands of Epplesheim, and in the tertiary deposits of Auvergne.

The extinct genus nearest allied to the living Tapirs, is the *Lophiodon*, which has six incisor teeth in each jaw, and the molars with transverse ridges: one species found at Argenton, was as large as a rhinoceros; but the two most abundant and best known genera are those designated by Baron Cuvier, *Palæotherium*, and *Anoplotherium*, from the gypsum quarries of Montmartre.

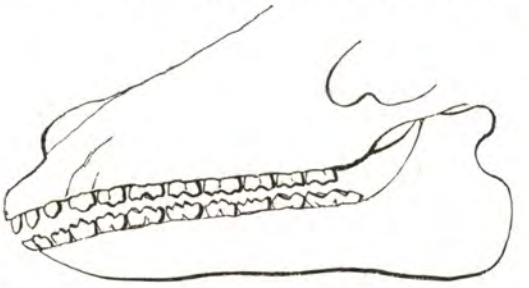
Palæotherium. — The animals of this genus resembled the Tapirs in the form of the head, and in having a short proboscis, but their molar teeth were more like those of the rhinoceros: their fore-feet had but three toes, instead of four as in the Tapirs. They had forty-four teeth; two pointed canines, longer than the incisors, in each jaw. The form and arrangement of the teeth are shown in *Lign.* 110. There are eleven known species; the largest, *Palæotherium magnum*, was of the size of a horse five feet high, with a massive head, and proboscis, and



Lign. 110.—Jaws and Teeth of Palæotherium magnum. ($\frac{1}{6}$ *nat. size.*)

short extremities.[1] *P. medium* was $\frac{1}{6}$ smaller than the American Tapir, and had longer and slighter legs and feet. *P. minus* was an elegant creature, as large as the Roebuck, with light and slender limbs.[2]

ANOPLOTHERIUM.—This genus is remarkable from its forming a connecting link between the ruminants and the pachyderms, having the cloven foot of the former, with canine teeth and other osteological characters of the latter; Baron Cuvier states that it combines affinities with the Rhinoceros, Horse, Hippopotamus, Hog, and Camel. The Anoplotherium has forty-four teeth disposed in a continuous uninterrupted series (see *Lign.* 111); a dental character only known in Man and the Quadrumana; viz. $\frac{6}{6}$ incisors; $\frac{1}{1}\frac{1}{1}$ canines, which are not larger than the incisors, and resemble them in form; and $\frac{7}{7}\frac{7}{7}$ molars, the anterior of which are compressed, and the upper posterior square, while those of the lower jaw have two crescents. The feet have but two developed toes, as in the ruminants; but there are species with small accessory toes, as in some of the animals of that order; but the metatarsal and metacarpal bones do not coalesce and form canon-bones, as in the other pachyderms, but always remain distinct. The Anoplotheria had a long and thick tail resembling that of the Otter, and it is supposed they were of aquatic habits, like the Hippopotamus. Seven or eight species have been discovered.



LIGN. 111.—JAWS AND TEETH OF THE ANOPLOTHERIUM COMMUNE. ($\frac{1}{6}$ *nat. size.*)

The collection contains specimens of other Eocene mammalia of the genera *Dichobune, Anthracotherium*, &c.[3]

CHAPTER VI.—PART V.

FOSSIL EDENTATA OF SOUTH AMERICA: THE MEGATHERIUM.

WE now arrive at the examination of the colossal skeleton which arrested our attention on entering this room—the *Megatherium;* an animal of an extinct family of *Edentata*, an Order of Mammalia, so named from the absence of incisor teeth, and of which the diminutive

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[1] See "Wonders of Geology," p. 255, fig. 2.

[2] Ibid. p, 255, fig. 4.

[3] See "Recherches sur les Ossemens Fossiles," for the history and anatomical characters of these extinct genera.

Sloths, Ant-eaters, and Armadillos, are existing examples; yet the largest of these does not exceed a dog in bulk, and is scarcely so high, while the fossil types surpass the rhinoceros in magnitude. The Edentata link together the *Unguiculata* and the *Ungulata*, for their toes are generally encased in thick skin, or scales, and terminate in strong, arched, solid claws. The extinct forms approach nearer the pachyderms than any existing genus of the Order, and they present transitional characters connecting the very dissimilar tribes of the *Ant-eaters* and the *Sloths*. The living Edentata are inhabitants of hot climates, and are abundant in South America; and there are a few species in Africa and Asia. The fossil species are for the most part from South America, but remains of Edentata have been discovered in the tertiary deposits of Central France and Germany, proving, that in the Eocene period animals of this order were inhabitants of Europe.

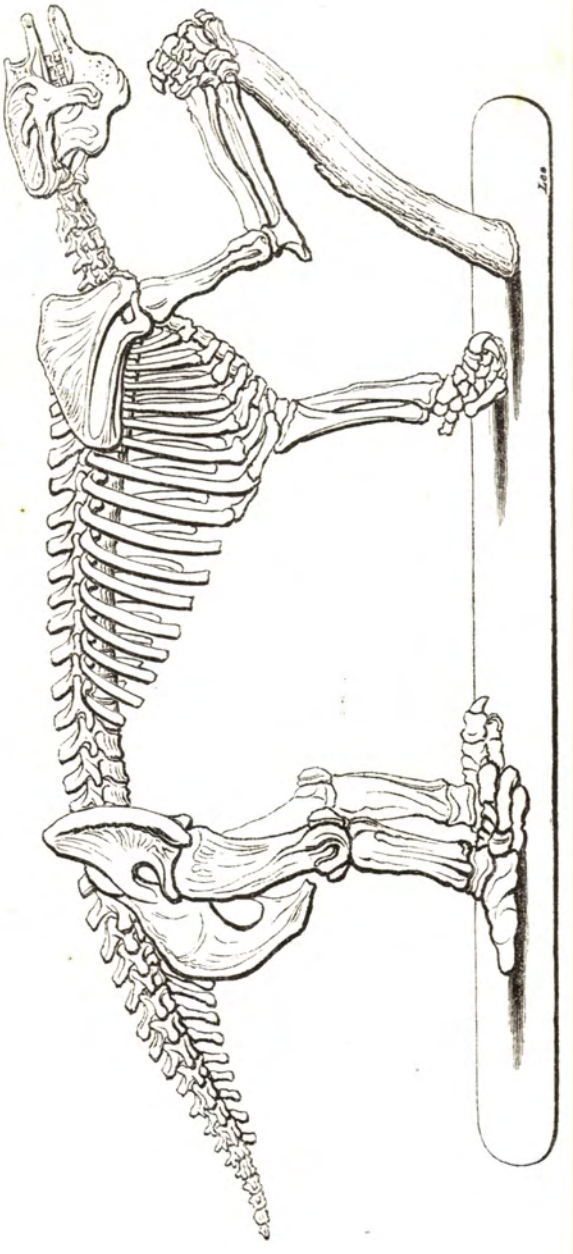
The bones of the extinct colossal Edentata are chiefly found in the alluvial loam and sand which compose the subsoil of the *Pampas* of South America; those vast plains which, for 900 miles, present a waving sea of grass. The deposits of the Pampas have evidently been formed in a bay or arm of the sea, into which floated the carcasses of the animals which then inhabited the neighbouring dry land.

Our distinguished traveller, Mr. Darwin, in relating the discovery of the *Scelidotherium* (pp. 77 and 480), states, "that the beds containing the fossil skeletons consist of stratified gravel and reddish mud, and stand only from fifteen to twenty feet above the level of high water; a proof that the elevation of the land has been inconsiderable since the great quadrupeds wandered over the surrounding plains, and that the external features of the country were then very nearly the same as now. The number of the remains of these quadrupeds imbedded in the vast estuary deposits which form the Pampas and cover the granitic rocks of Banda Oriental, must be extraordinarily great. I believe, a straight line drawn in any direction through the country would cut through some skeleton or bones. As far as I am aware, not one of these animals perished, as was formerly supposed, in the marshes or muddy river-beds of the present land, but their bones have been exposed by the streams intersecting the subaqueous deposit in which they were originally imbedded. We may conclude that the whole area of the Pampas is one wide sepulchre of these extinct gigantic quadrupeds."[1]

The Megatherium.—This stupendous extinct animal of the Sloth tribe was first made known to European naturalists by a skeleton, almost entire, dug up in 1789, on the banks of a river in South America, named the Luxan, about three-miles south-east of Buenos Ayres; the specimen was sent to Madrid, and fixed up in the Museum, in the form represented in numerous works on natural history. A second skeleton was exhumed at Lima, in 1795; and of late years Sir Woodbine Parish, Mr. Darwin, and other naturalists, have sent bones of the Megatherium, and other allied genera, to England.

The model of the Megatherium, *Lign.* 112, has been constructed with great care from the original bones, in the Wall-cases 9, 10, and in the Hunterian Museum. The attitude given to the skeleton, with the

[1] "Journal of a Naturalist," by Charles Darwin, Esq. F.R.S. &c.

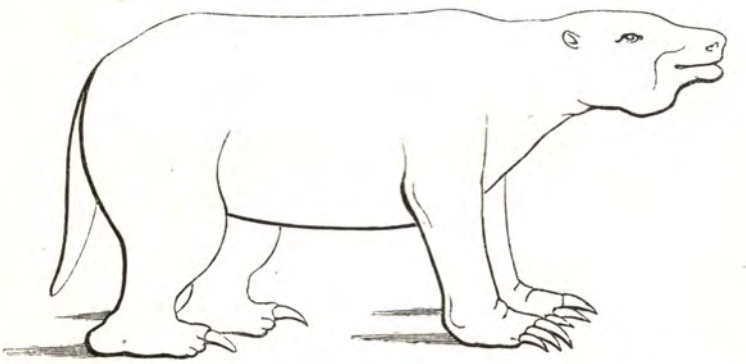


LIGN. 112.—SKELETON OF THE MEGATHERIUM CUVIERI (AMERICANUM).

(*Height*, 8 *feet*; *length*, 12 *feet*.)

right arm clasping a tree, is of course hypothetical; and the position of the hinder toes and feet does not appear to be natural; altogether, however, the construction is highly satisfactory, and a better idea of the colossal proportions of the original is conveyed by this model, than could otherwise have been obtained. The skull of this creature is short and truncated, and the zygomatic bone sends off a large descending apophysis which is a remarkable peculiarity. The molar teeth, of which there are five on each side the upper jaw, and four in the lower, are hollow prismatic cylinders, straight, and from seven to nine inches long, and implanted the greater part of their length in deep sockets; there are no other teeth, and the crowns of the molars are so constructed as always to present two cutting, cuneiform, salient angles, in consequence of the mutual adaptation of the corresponding surfaces of the upper and lower series. The feet are nearly equal; the entire fore-foot is about a yard in length. The outer toes are destitute of nails, the others have unequal phalanges, the median being the longest and largest. The pelvis is of enormous dimensions, and very solid; the iliac bones are at right angles with the spine, and extremely rugous; their margins form two projecting branches, measuring 4½ feet across, a dimension exceeding that of the same parts in any living terrestrial mammalian.

The most remarkable character of this portion of the skeleton is that the cotyloid cavity is directed entirely downwards, so that the femur supports the body without any obliquity; a structure that must have contributed to the solidity and strength of the hinder part of the body. The femur is three times as thick as that of the largest Elephant, and its length scarcely twice that of the breadth. The tail is very thick and strong; there is a fine series of caudal vertebræ in Upright-Case 4.



LIGN. 113.—RESTORED OUTLINE OF THE MEGATHERIUM GIGANTEUM.

(*The original* 12 *feet in length.*)

From the osteological characters thus cursorily noticed, it is obvious that the Megatherium was a bulky and powerful creature, presenting in its general form the outline given in *Lign.* 113. The structure of the teeth is analogous to that of the Sloths, and indicates the food of the

original to have consisted of plants and leaves or the young branches of trees. My friend Sir Woodbine Parish, whose long residence in South America enabled his active and sagacious mind thoroughly to investigate the phenomena connected with the ancient fauna of that country, has solved the problem as to the source whence the Megatheria and allied herbivorous animals could have derived support, by pointing out the Agave or American Aloe, as yielding an ample supply of food, and of a kind, for the comminution of which the teeth of the colossal edentata appear to have been specially adapted.

Mylodon.—Of this genus, which is closely allied to the Megatherium, there are bones, teeth, and jaws from South America, in Room II., *ante*, p. 77.[1]

With the huge animals above described, were associated those not less gigantic in relation to their modern prototypes, the *Glyptodon*, (*ante*, p. 359,) and the *Chlamydotherium*, which were covered by a tesselated osseous cuirass, like the existing Armadillos of the present day.

Scelidotherium. — The animals of this genus are allied to the Megatherium. Mr. Darwin obtained an almost entire skeleton of the *S. leptocephalum;* the original must have been as large as a Rhinoceros. Four species have been discovered; there are some fine bones of two or three species from the caves of Brazil, in Wall-case *C.*

Such were the gigantic mammalia that inhabited the dry land of South America at a comparatively recent period; and it is worthy of especial consideration, that though these types have been long extinct, Sloths, Ant-eaters, and Armadillos, are still the characteristic mammalia of that country, and these diminutive forms are the only living representatives of the colossal Edentata of the ancient world.

CHAPTER VI.—Part VI.

FOSSIL MAMMALIA OF THE CAVERNS.

Ossiferous Caves of the Brazils.—*Wall-case C.*—The fossil remains in this cabinet were obtained by Dr. Lund and M. Claussen, from certain limestone caverns in the Brazils, which, like those of Europe, abound in bones of mammalia, imbedded in a reddish coloured loam, and more or less incrusted with stalagmite. The animals belong for the most part to genera still inhabiting the American Continent, intermingled with the extinct types of some of the Edentata,

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[1] See "Wonders of Geology," p. 168. A splendid skeleton of this animal is preserved in the Hunterian Museum, and is described and illustrated in a "Memoir on the Mylodon robustus, by Professor Owen;" published by the Royal College of Surgeons.

of which we have already spoken; as, for example, the *Scelidotherium, Glyptodon, Clamydotherium,* &c.; of these there are many perfect bones, and portions of the dermal cuirass of the two latter. In this collection there are several bones of a very large species of that extraordinary carnivore described in a former section, (*ante,* p. 400,) the *Machairodus,* and of existing genera of mammalia, including Monkeys, Opossums, &c.; there are also shells of the large *bulimus,* a common terrestrial mollusk of South America.

There are likewise remains of a species of Hyena and Horse; the former genus, which abounded in Europe during the newer tertiary and drift period, is now only known to exist in Asia and Africa; and the latter was extinct in South America when the Spaniards invaded that country, though numerous relics occur of a species of Equus, that was contemporary with the colossal Edentata, whose skeletons are imbedded in the Pampas. Thus the ancient Brazilian fauna differs as essentially from the modern one, as that of the Cave period of Europe from the existing assemblage of terrestrial mammalia.

An interesting fact relating to the Brazilian caves is worthy of record. M. Claussen, in the course of his researches, discovered a cavern, the stalagmitic floor of which was entire. On penetrating the sparry crust he found the usual ossiferous bed, but pressing engagements compelled him to leave the deposit unexplored. After an interval of some years M. Claussen again visited the cavern, and found the excavation he had made completely filled up with stalagmite, the floor being as entire as on his first entrance. On breaking through this newly formed incrustation, it was found to be distinctly marked with lines of dark-coloured sediment, alternating with the crystalline stalactite. Reasoning on the probable cause of this appearance, M. Claussen sagaciously concluded that it arose from the alternation of the wet and dry seasons. During the drought of summer, the sand and dust of the parched land were wafted into the caves and fissures, and this earthy layer was covered during the rainy season by stalagmite, from the water that percolated through the limestone, and deposited calc-spar on the floor. The number of alternate layers of spar and sediment tallied with the years that had elapsed since his first visit; and on breaking up the ancient bed of stalagmite, he found the same natural register of the annual variation of the seasons; every layer dug through presented a uniform alternation of sediment and spar: and as the botanist ascertains the age of an ancient dicotyledonous tree from the annual circles of growth, in like manner the geologist attempted to calculate the period that had elapsed since the commencement of these ossiferous deposits of the cave; and although the inference, from want of time and means to conduct the inquiry with precision, can only be accepted as a rough calculation, yet it is interesting to learn, that the time indicated by this natural chronometer, since the extinct mammalian forms were interred, amounted to many thousand years.[1]

As in the bone-caves of England, France, and Germany, relics of human skeletons have been found in the upper layers of the detritus

[1] Communicated to me by Mr. Waterhouse.

forming the floor of the Brazilian caves. Dr. Lund, from the condition and situation of these remains, concluded that they belonged to an ancient tribe that was coeval with some of the extinct mammalia. Portions of human crania from these caverns are placed with the Guadaloupe skeleton in Wall-case *D*.

Ossiferous Caves of Torquay and Kirkdale.—*Wall-case E.*—The contents of this Case consist of mammalian remains from the caves of Kirkdale in Yorkshire, Kent's Hole, near Torquay in Devonshire, and of Gailenreuth in Franconia. The nature of such accumulations has already been so fully discussed (*ante*, p. 396), that a brief notice will suffice. The fossils belong for the most part to extinct species and genera of carnivora. In the upper part of the cabinet there are many fine teeth and jaws of the usual cave Hyenas and Bears; and teeth of the large tiger-like animal, the *Machairodus latidens*, described in a former chapter (*ante*, p. 400). There are likewise jaws and teeth of Foxes, Weasels, Rats, Mice, &c., from Kirkdale Cave; and of a species of Badger, Otter, Polecat, and Stoat, from Kent's Hole, Torquay; the latter are part of the collection of the late Rev. J. Mac Enery.

The cave at Torquay is an extensive chasm in the limestone strata, extending 600 feet in length, with many lateral fissures. The lower part of the cave is filled up to a thickness of twenty feet with reddish sandy loam, full of fossil bones of carnivorous animals.[1] This is covered by a layer of stalagmite, a few feet thick, which forms the floor of the cavern. Upon this is a slight covering of earthy matter, in which have been found patches of charcoal, a few human bones, and fragments of coarse ancient pottery. Upon breaking through the sparry floor the ossiferous deposit is exposed; and imbedded with the fossil bones several flint-knives, stone arrow and spear-heads, were discovered. These instruments are of the same kind as those found in the early British tumuli on the adjacent hills, and unquestionably belong to the same period.

These facts have given rise to much curious speculation as to the contemporaneity of these remains of man and human art, with the extinct species of animals whose bones are entombed in the cave. Kent's Hole, Banwell Cave, and all the ossiferous fissures and caverns I have examined, appear to me to have been mere rents in limestone rocks, which were filled with drift while submerged in shallow water; and into which the mutilated carcasses of land animals may have been carried by subaqueous currents. As the bones, though broken, are rarely waterworn, and the fragments even retain their sharp edges, they must have been more or less protected by the muscles and skin; and the extreme freshness of the surface of many of the specimens supports this opinion. Upon the elevation of the land, these caves were raised above the water, and gradually drained, during which the formation of stalagmite commenced from the percolation of solutions of calcite through the superincumbent beds of limestone. As soon as Kent's Cave was accessible from the land, and before the formation of the stalagmitic

[1] See Dr. Buckland's "Reliquiæ Diluvianæ," for details; and "Wonders of Geology," 6th. Edit. p. 181, for a concise view of the phenomena.

floor, some of the wandering tribes of the early Britons may have prowled into the recess, or occasionally sought shelter there; and stone implements, bones, or any hard substances left on the ground, would soon sink a few feet into the soft ossiferous mud, and become hermetically sealed up, as it were, by the stalagmitic deposit.

From the phenomena thus rapidly surveyed, we learn that the hills, plains, and forests, of Europe, were once inhabited by unknown species of herbivora, and carnivora, belonging to genera, some of which are annihilated, and others are almost entirely restricted to southern climates; that some of the caves were tenanted by successive generations of Bears, Hyenas, Wolves, &c.; and that all these races have become extinct, except the few allied species which still inhabit the European Continent, and Islands. In England, the only living representatives of the three families of carnivora which swarmed in these latitudes during the Mammoth period, are the *Fox*, of the dog tribe, the *Wild-cat*, of the feline order, and the *Badger*, of the bear family.

CHAPTER VI. — PART VII.

FOSSIL HUMAN SKELETON.

Wall-case D.—About forty years since, great interest was excited by the discovery of several human skeletons, male and female, imbedded in limestone on the north-east coast of the Isle of Guadaloupe; and the specimen now before us, found on board a French vessel captured by one of our cruisers, and presented to the British Museum by Admiral Sir T. Cochrane, afforded English naturalists an opportunity of investigating the nature and age of these first known examples of the bones of *Man* in a fossil state. An excellent memoir by the eminent mineralogist and geologist Mr. König, was published in the "Philosophical Transactions" for 1814, in which the nature of these petrifactions was fully elucidated.

In this specimen the skull is wanting, but the spinal column, many of the ribs, the bones of the left arm and hand, of the pelvis, and of the thighs and legs, though somewhat mutilated, are distinctly seen. The bones still contain some animal matter, and the whole of their phosphate of lime.[1] An entire skeleton was dug up in the usual position of burial adopted by the Peruvians, and is now in the Jardin des Plantes.[2]

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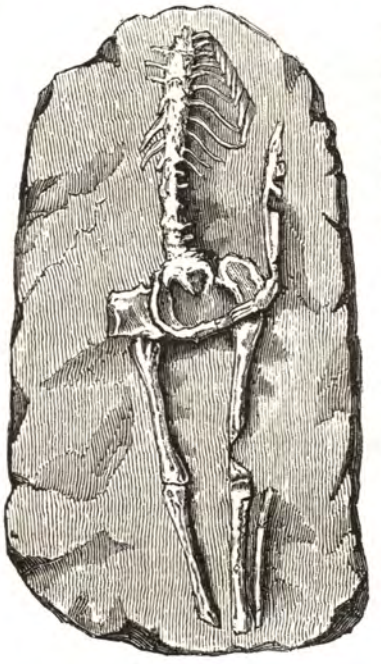
[1] The skull of this very skeleton is said to be in a museum in South Carolina, having been purchased of a French naturalist, who brought it from Guadaloupe.

[2] See "Wonders of Geology," p. 87.

These fossil human skeletons were extracted from the sloping bank of limestone that extends from the base of the high cliffs of the island to the sea-shore, and is almost wholly submerged at high tides, as shown in the annexed diagram (*Lign.* 115). This limestone is composed of consolidated sand, and the detritus of shells and corals of species that inhabit the neighbouring sea. Land-shells, fragments of pottery, stone arrow-heads, carved wooden ornaments, and detached human bones, are occasionally found imbedded in it. A polished slab of this limestone forms the top of the table in front of Wall-case *D*. This rock is a modern concretionary limestone, consisting of the detritus of shells and corals cemented together by infiltration of carbonate of lime from the percolation of water; a common formation along the sea-shore of tropical countries; as, for example, in the Bermudas, where limestone, compact enough for building, is rapidly formed by a similar process.[1]



LIGN. 114.
FOSSIL HUMAN SKELETON; FROM GUADALOUPE.
(*The original 4 feet 2 inches long, by 2 feet wide.*)

The human skeletons of Guadaloupe are the relics of a tribe of Gallibis, that were slaughtered by the Caribs in a conflict that took place near the spot about 150 years ago; the slain were buried in the sand on the shore, which subsequently became indurated by the process above described.

Fossil human skeletons have also been found in solid calcareous tufa near the river Santa in Peru. Bones belonging to some scores of individuals were discovered in travertine, containing some fragments of marine shells which retain their original colour; yet this bed of stone is covered by a deep vegetable soil, and forms the face of a hill crowned with brushwood and large trees.

From the facts thus briefly noticed,[2] the reader will perceive that the occurrence of remains of Man with those of extinct animals, in a deposit overlaid by a thick mass of solid rock, must not be regarded as affording a certain proof that the human bones are as ancient as those of the quadrupeds with which they are associated.

In Europe, the first appearance of MAN, as indicated by the remains

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[1] "Wonders of Geology," p. 84.

[2] For a fuller consideration of this problem, I would beg to refer the reader to my "DISCOURSE ON THE CONNEXION BETWEEN ARCHÆOLOGY AND GEOLOGY," previously cited.—*Archæological Journal*, January 1851.

of human skeletons and works of art, was immediately after the great inundation which spread the rolled boulders and detritus of the *Drift* or *Diluvium* over the valleys and plains, and into the caverns and fissures, in which the bones of the mammalia that inhabited the land are found entombed. What species, now extinct, were existing at the period of the first advent of the human race into Europe, it is scarcely possible to determine. The Irish Elk, two or three species of Bos, and probably a species of Horse, Beaver, and Bear, are apparently the only lost forms which the facts at present known point out as contemporaries of the aboriginal tribes of the British Islands and the neighbouring Continent. In the ancient tertiary strata, though the bones of many species of quadrupeds of existing genera, and even some species believed to be identical, abound, yet no vestiges of Man or of his works have been detected. While, therefore, we may reasonably expect to find fossil human remains in strata of higher antiquity than any in which they

LIGN. 115. PLAN OF THE CLIFF AT GUADALOUPE.

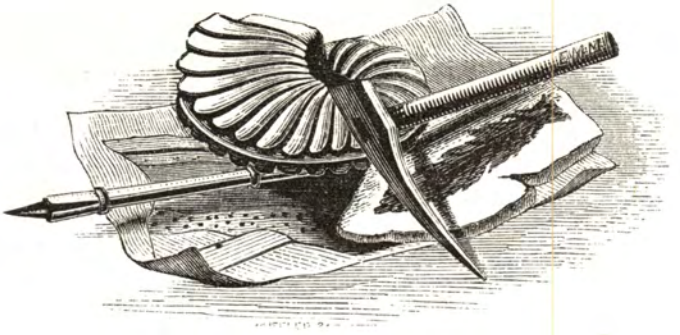
a. Ancient rocks.
b. Modern limestone, in which the human skeleton was imbedded.

have hitherto been observed, it does not seem probable that traces of Man's existence will be met with in the *Eocene*, or ancient tertiary formations; for, notwithstanding the occurrence of existing genera and species of mammalia, even of that race which approaches nearest to Man in its physical organisation,—the *quadrumana* or Monkey-tribes,—there are no just grounds for assuming that physical evidence will be obtained by which the existence of Man, and, consequently, of the present order of things, may be traced back to that remote era.

In reference to this problem, I entirely concur in the opinion expressed by Professor Whewell,[1] "that the gradation in form between man and other animals is but a slight and unimportant feature in contemplating the great subject of the origin of the human race. Even if we had not Revelation to guide us, it would be most unphilosophical to attempt to trace back the history of man, without taking into account the

[1] Anniversary Address of the Geological Society of London.

most remarkable facts in his nature; the facts of civilization, arts, government, speech;—his traditions—his internal wants—his intellectual, moral, and religious constitution. If we will attempt a retrospect, we must look at all these things as evidence of the origin and end of man's being; and when we do thus comprehend in one view the whole of the argument, it is impossible for us to arrive at an origin homogeneous with the present order of things. On this subject the geologist may therefore be well content to close the volume of the earth's physical history, and open that divine record which has for its subject the moral and religious nature of Man."



APPENDIX.

A. page 94.—*"An Account of some enormous Fossil Bones of an unknown species of the Class Aves, lately discovered in New Zealand;"* by the Rev. W. Colenso, was published in the "Tasmanian Journal," 1842; and republished in the "Annals of Natural History." The length to which the text has extended, forbids the insertion of an abstract of this able commentary on the nature and relations of the Moa and its kindred.

B. page 96.—*Mr. Walter Mantell's Collection of Fossil Remains of the extinct Birds of New Zealand, in the British Museum, Room II.* The first collection sent to England by my son, in 1847, consisted of nearly 900 specimens; such an assemblage of the fossil bones of Birds was, I may venture to affirm, never before seen in Europe; every palæontologist who saw it expressed astonishment at its extent and variety, and no one more than Professor Owen, to whom I gave the exclusive privilege of describing the specimens.[1] It was catalogued by my son as follows:—

Birds' Bones.—Crania and mandibles, 19; vertebræ, 250; sterni, 7; pelves, 30; femora, 37; tibiæ, 42; fibulæ, 35; tarso-metatarsals, 40; phalangeals, 200; unguals or claw-bones, 30; ribs, 30; egg-shells, 36 portions.

Seals.—Jaws and teeth, portions of crania, vertebræ, ribs, scapulæ, bones of the extremities.

Terrestrial Mammalia.—One femur of a species of Dog.

C. page 111.—*Professor Owen's Memoirs on the Dinornis, &c.* are published in the "Transactions of the Zoological Society of London:" they consist of five parts:—I. "Notice of a Fragment of the Femur of a

[1] The following is an extract from a letter now before me from Professor Owen, dated "Royal College of Surgeons, Christmas Day, 1847." —"I feel very sensibly the mark of kindness and confidence which you have given me in placing your son's unique rarities in my hands for description; the more so as this liberal and generous conduct contrasts with that of others from whom I had expected better things."

Gigantic Bird of New Zealand," vol. iii. November, 1839. II. "On Dinornis, an extinct Genus of Struthious Birds," &c. with 15 plates, 1844. III. "On Dinornis, Part II." &c. with eleven plates, 1846. IV. "On Dinornis, Part III." &c. with five plates, illustrative of the crania, &c. collected by Mr. Walter Mantell, and now in the British Museum, 1848. V. "On Dinornis, Part IV." &c. with four plates, 1850.

D. page 117. Feet of Dinornis robustus.—As the specimens described in the text are the only perfect series of the bones of the feet hitherto found in juxtaposition, the dimensions of the principal parts will interest the Ornithologist; but I must refer for details to my Memoir on the Geology of New Zealand, "Journal of the Geological Society of London," vol. vi. p. 338; or to "Pictorial Atlas of Organic Remains," p. 10.

Tarso-metatarsal: length, 17 inches; circumference of proximal end, $11\frac{3}{4}$; of the distal end, $15\frac{1}{2}$.

Toes: length of the *inner toe*, $9\frac{1}{2}$ inches; *middle toe*, $11\frac{1}{2}$; *outer toe*, $9\frac{1}{3}$.

Middle toe: length of first phalanx, $4\frac{1}{4}$ inches; second, $2\frac{1}{2}$; third, $1\frac{3}{4}$; fourth or ungual bone, 3 inches.

E. page 229.—The following is another extract from the eloquent Address of Sir Charles Lyell on that occasion, (Feb. 20, 1835.)—"The Wollaston Medal has been awarded to Mr. Mantell for his discoveries in 'Fossil Comparative Anatomy, particularly of the genera Iguanodon and Hylæosaurus.' There are few of you, gentlemen, I believe, entirely unacquainted with the results of Mr. Mantell's investigations in this department of science,—few who have not either read of them in his works, or seen them in his splendid Museum. That collection, now at Brighton, which has already been visited by thousands of persons, is of itself a monument of original research and talent, well deserving, even if he had never written on the subject, as high a mark of distinction as the Society has conferred upon Mr. Mantell this day. It is an assemblage of treasures which the mere industry of a collector could never have brought together, and which wealth alone, even had Mr. Mantell possessed it, could not have purchased. It required his zeal, inspired by genius and directed by science, to bring to light, and, as it were, call into existence, so many monuments of the former state of the animate creation. Gentlemen, you will, I am sure, allow me to dwell somewhat at length on this topic, as one which is to me of no ordinary interest, for it is now nearly twenty years since I first had the good fortune to become acquainted with Mr. Mantell; before I had the honour of knowing any one of the leading members of this Society; before, indeed, I had heard of the existence of the Society itself. At that time the collection at Lewes was in its infancy, yet contained osteological remains of that class, for the illustration of which it has since become so celebrated; even at that time my friend had indulged sanguine anticipations, from seeing only a few bones and teeth, of the splendid discoveries he should make in regard to these gigantic saurians; even then he foresaw some of the results which have since been realized. I had afterwards many opportunities of revisiting Lewes, more than once in

company with Dr. Buckland, and after each interval found Mr. Mantell's Museum enriched with new discoveries, some of his former theories and conjectures confirmed, and new views opening upon his mind. Mr. Greenough has pointed out to you how strikingly a recent discovery of an assemblage of the bones of the Iguanodon grouped and imbedded in one mass of rock, has shown the sagacity with which Mr. Mantell had put together the disconnected remains when first discovered. All the bones in that specimen are such as he had previously considered as belonging to the Iguanodon, with no intermixture of those which he had rejected as probably referable to other saurians."[1]

F. page 232.—*Baron Cuvier on the Iguanodon.* For the reasons stated in the text, I would beg the palæontologist who may feel any interest on this subject to peruse M. Cuvier's remarks on the teeth of the Iguanodon, in "Ossemens Fossiles," tome v. pp. 351, 352. The only other notice of the Iguanodon by this illustrious philosopher, is in the edition of his "*Discours sur les Revolutions de la Surface du Globe,*" published in 1826. "Les sables ferrugineux placés en Angleterre au-dessous de la craie, contiennent en abondance des crocodiles, des tortues, des mégalosaurus, et surtout un reptile qui offrait encore un caractère tout particulier, celui d'user ces dents comme nos mammifères herbivores. C'est à M. Mantell, de Lewes en Sussex, que l'on doit la découverte de ce dernier animal, ainsi que des autres grands reptiles de ces sables inférieurs à la craie :—il l'a nommée *Iguanodon*." In August 1830, I submitted to Baron Cuvier, then in London, many teeth and bones from Tilgate Forest, and was confirmed in my opinion as to the probable dentition, and structure of the maxillary organs, of the Iguanodon, by his unqualified approval; and so much was his interest excited, that he made arrangements to visit me at Lewes the following week; but unfortunately the revolution broke out at Paris, and M. Cuvier was summoned from England: we never met again.

G. page 280.—*Drawings of Wealden Reptiles presented to Professor Owen.* The Wollaston fund, awarded me with the medal by the Geological Society in 1835, amounting to between 20*l.* and 30*l.*, was expended on drawings (by Mr. Dinkel, now of 17, Upper King Street, Bloomsbury,) of the principal bones of the Iguanodon, Hylæosaurus, &c. in my collection, with a view to publication: the Maidstone Iguanodon, the large specimen of Hylæosaurus, and figures of both slabs of the Goniopholis, (in Room III. Case *A*,) were of imperial 4to size; the remainder were in 4to, and comprised more than one hundred figures. In 1841, the state of my health rendering it improbable that I should ever be able to resume my scientific researches, I presented the whole of these beautiful drawings to Professor Owen, who then contemplated a work on British Fossil Reptiles. A plate of reptilian teeth in Professor Owen's "Odontography," and the two lithographs of the Maidstone Iguanodon

[1] These remarks refer to the Maidstone Iguanodon, then recently discovered. The Members of the "*Palæontographical Society*" are requested to compare the above statement with that given in the last "Monograph on Cretaceous Reptiles."

in the "Palæontographical Monograph" of the present year, are the only drawings of that series hitherto published.

H. page 332.—*Memoirs on Wealden Reptiles, &c. by the Author in the "Philosophical Transactions."* I. "Notice on the Iguanodon, a newly discovered Fossil Reptile," &c.—*Philos. Trans.* 1825. II. "Memoir on the Iguanodon, Hylæosaurus," &c. 1841. III. "On the Maxillary and Dental Organs of the Iguanodon," 1848. IV. "Observations on the Osteology of the Iguanodon and Hylæosaurus," 1849. V. "On the Pelorosaurus," &c. 1850. VI. "On the Dermal Spines of the Hylæosaurus," 1850. VII. "On the Fossil Remains of Turtles from the Chalk of the S.E. of England," *Philos. Trans.* 1841. VIII. "On the Fossil Remains of the soft Parts of Foraminifera in Chalk and Flint." *Philos. Trans.* 1846.

I. page 335.—*The Author's Collection of Fossils from the Chalk and Wealden Deposits of the South-East of England, &c.* "When the first edition of this work ('The Wonders of Geology') appeared, my collection, consisting of upwards of 20,000 specimens, was exhibited at Brighton by the Sussex Scientific Institution as the *Mantellian Museum*, with a view to its permanent establishment as the basis of a County Museum. That expectation was, however, defeated; for though I would willingly have made any pecuniary sacrifice to accomplish what appeared to me so desirable an object, yet after the decease of my noble and lamented friends the late Earl of Egremont, and the Earl of Munster, who ardently and liberally supported the measure, the plan was abandoned. I therefore, in compliance with the suggestion of my scientific friends, disposed of the entire collection to the Trustees of the British Museum."—*Extract from the Preface to the Second Edition of the "Wonders of Geology."* The sum given for this collection, on which I had expended at least 7,000*l.* during a period of 25 years, was 4,000*l.*; the expenses and risk of removal from Brighton to London, were incurred by the Trustees.

K. page 367.—*Mr. Hawkins's Collection.* The specimens figured in the first edition of Mr. Hawkins's "Memoirs of Ichthyosauri," &c. were valued by Dr. Buckland and myself, at the request of the Trustees of the British Museum. The collection consisted of several hundred specimens, and the total amount paid for the same was 1,250*l.* Among the items were;—The large Ichthyosaurus, (*ante*, p. 381), 210*l.* Cranium with orbital plates, (Pl. V.) 25*l.* Ichthyosaurus, (Pl. VII.) 100*l.* Plesiosaurus; the matchless specimen in Case *D.* (*ante*, p. 340), 200*l.* See "*Notes on the Prices of Fossils*," in Mr. Charlesworth's "London Palæontological Journal," No. I. p. 13.

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ERRATA.

Page 27,	line 9	from bottom,	*for* head, *read* bud.
93,	— 9	—	*for* 1851, *read* 1850.
115,	— 24	—	*for* fibula, *read* fibulæ.
129,	— 5	—	*for* Diamodea, *read* Diomedea.
187,	— 13	—	*for* more, *read* less.
288,	— 24	—	*for* thighbone, *read* humerus.
—	— 23	—	*for* specimen, *read* thighbone.
—	— 16	—	*for* caudyloid, *read* condyloid.

FINIS.

R. CLAY, PRINTER, BREAD STREET HILL.